Appendix D Static GPS Survey Examples

Section I Survey No. 1: HORIZONTAL CONTROL GPS SURVEY (Ukiah Airport, California)

D-1. Planning Phase

The GPS survey was planned for 25 April 1989 in the vicinity of Ukiah Airport, Ukiah, California.

- a. A diagram of the project area is shown in Figure D-1.
- b. Four SPS (C/A-code) GPS carrier phase tracking receivers were used for the survey, one person per receiver. In actuality, because the personnel were inexperienced in conducting a GPS survey, a fifth person was also used. The fifth person was used as a "runner" who can be called upon during the survey to aid in smoothing out any complications (e.g., aiding in overall communication and coordination, parts retrieval in case of breakdown, bad power source, blown fuse, misplaced equipment, forgotten measurement device or power cord, as well as any other possible complication). Communication between personnel was by two-way radio. Care was taken in choosing and operating the two-way radio near the GPS survey so that the radio transmitter and receiver chosen, when in operation, would not interfere with the GPS receiver.
- c. Prior to data collection, the stations were inspected and found to be acceptable (easy accessibility, no obstruction or possible multipath sources, and at least 20° satellite visibility above the horizon).
- d. The date 25 April 1989 corresponds to Julian calendar day 115. Calpella, Perry, and Ukiah Airport were stations with established horizontal control. Pier 1 and Pier 2 were stations requiring horizontal coordinates accurate to 1:10,000 (refer to Figure D-2). Therefore, the following station conventions for Session 1 of the survey were:

Pier 1 - Station 20011151 Pier 2 - Station 20021151 Calpella - Station 20131151 Ukiah Airport - Station 20141151

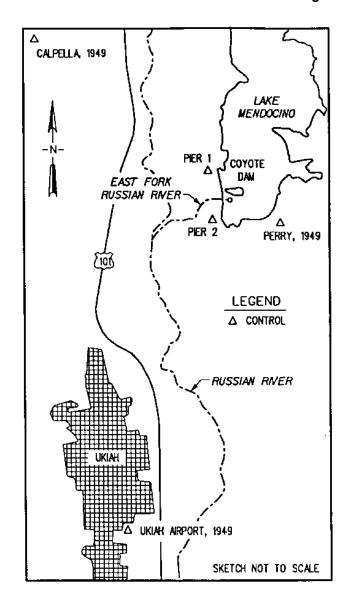


Figure D-1. Ukiah project area

It is important to note that this station convention was used for this survey because the receiver used only allowed numeric input of station names. Most newer receivers allow alphanumeric inputs for station names which provides more flexibility in station naming. (Consult the GPS manufacturer literature for further explanation and guidance on the receiver's station naming convention.)

e. A satellite visibility plan (a software package that produces a hard copy listing of satellite constellations and

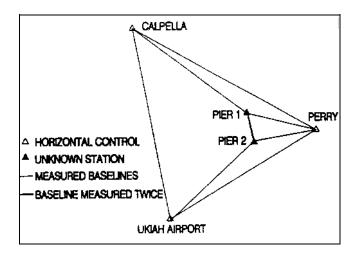


Figure D-2. GPS project diagram (Ukiah)

time availability based on ephemerides) was run for the project location. The satellite visibility was run with the most up-to-date ephemeris for the period of observation, using four-satellite visibility, and with a cutoff elevation angle of 20°. An up-to-date ephemeris was used to ensure the satellite visibility formulated was the most accurate. Four-satellite visibility was run in order to formulate accurate 3D solutions. A cutoff elevation of 20° was chosen in order to minimize any diffusion or dispersion of the signal by the atmosphere which in turn may cause errors in the solution as the satellites pass near the horizon. The satellite visibility plan produced for the Ukiah project is shown below.

All-In-View PDOP for Ukiah

Date: 25 Feb 1990 Latitude: 39° 12' 30" N Time: 4:00 -> 4:00 Longitude: 123° 10' 30" W

Cutoff Elevation: 20 Zone: - 7:00

	Time	Time		PDO	P
Satellite Constellation	Rise	Set	dT	Rise	Set
6 9 11 13	21:55	22:03	0:08	4.9	5.0
6 9 11 12 13	22:02	22:33	0:30	3.8	3.6
6 9 11 12 13 19	22:32	23:18	0:45	3.2	3.3
3 6 9 11 12 13 19	23:17	23:48	0:30	2.9	3.0
3 9 11 12 13 19	23:47	1:08	1:20	4.2	4.2
3 11 12 13 19	1:07	1:22	0:15	4.9	5.0
3 12 13 19	1:22	2:20	0:58	22.7	31.6

The portion of the satellite visibility where the PDOP is near 5.0 m/m or below are times when the satellite geometry is conducive for conduct of a survey. A PDOP near or below 5.0 m/m does not guarantee a successful survey

but it does indicate good satellite geometry during that moment of the survey (see Chapter 5 for further information on PDOP).

f. From the satellite visibility plan, it was decided to conduct three sessions during the survey. Travel between survey sites, time to set up and take down the equipment before and after the survey, receiver warm-up time, time of survey (at least an hour allotment for survey data collection, but more than an hour if at all possible), and possible time loss due to unforeseeable problems or complications were taken into account before deciding on a specific session schedule. The final survey session schedule is shown in Table D-2.

Table D-2 Final Survey Session Schedule				
Session	Start Time	Stop Time		
1	21:55	22:55		
2	23:38	00:38		
3	01:23	02:20		

It was further decided which stations would be occupied during each session. Station occupation was designed to minimize travel time and to add to the overall efficiency of the survey. The station occupation schedule was planned as shown in Table D-3.

Session	Station	Station	Station	Station
1	Calpella	Ukiah Airport	Pier 1	Pier 2
2	Calpella	Perry	Pier 1	Pier 2
3	Ukiah Airport	Perry	Pier 1	Pier 2

g. A GPS station observation log is generally filled out prior to conduct of the survey. An example of a GPS log is shown in Figure D-3. The log must be filled out for each of the stations occupied in order to have a written record of the actual survey and as an aid for the personnel occupying each of the stations.

h. Portions of the GPS station observation log were filled out prior to data collection. These portions included the station name, start date, GPS 8-character ID for each session, project name, project location, observer name, approximate receiver position (latitude, longitude, and elevation), session scheduled start and stop times, and requisite tracking equipment information. In this case, six GPS station observation logs were filled out, one each

PROJECT NAME		LOCA	LITY	
OBSERVER		AGENCY/FIRM		
RECEIVERS/N				
ANTENNA		S/N		
DATA RECORDING T		S/N		
TRIBRACH			CALIBRATED:	
****				*****
STATION: NAME NUMBER	SESSION 1	SESSION	2 SESS	ION 3
DAY OF YEAR				
DATE MM DD YY		- ———	<u> </u>	
UTC TIME OF OBSERVATION	START STO	P START S	TOP START	STOP
******	******	***** *******	***	*****
	ANTENNA H	EIGHT MEASUREM	ENTS	
	SESSION 1	SESSION	2 SESSIC	ON 3
SLOPE @				
BEGINNING	IN= M		_ MIN=	=M
MI	1 = M	MN =	_ M MN = _	M
GY OPP O				
SLOPE 0		_{IN=} ·		
	N=M	<u>WN =</u>	MIN=	
111	- <u></u> H		_ M MN = _	M
MN ADJ TO VERT:	м		M	М
*****		****		
PROGRAMMED I	FIELD PROGE	RAMMED FIELD	PROGRAMMED	FIELD
REFPOS POS	SITION REI	FPOS POSITION	REFPOS PO	SITION
LAT				
<u></u>				
LONG				
LONG	<u> </u>			
LONG				
LONG HT PDOP EVS TO PRACK LOCAL	ACTIIAI. SCH	IEDIII ED ACTIVAL	SOUPDINED A	
LONG HT PDOP EVS TO FRACK LOCAL FIME: SCHEDULED	ACTUAL SCH	HEDULED ACTUAL	SCHEDULED	ACTUAL
LONG HT PDOP SVS TO FRACK LOCAL FIME: SCHEDULED	ACTUAL SCE	HEDULED ACTUAL	SCHEDULED A	ACTUAL
LONG HT PDOP SVS TO FRACK LOCAL FIME: SCHEDULED				

Figure D-3. Example GPS station observation log (front and back) (Continued)

******	U.S. ARMY CORPS	GGING SHEET	
***********	SESSION 1		
ANT CABLE LENGTH		.	
POWER SUPPLY		 	
WEATHER CONDITIONS			
MONUMENT TYPE			
EXACT STAMPING			
AGENCY CAST			
IN DISK ***********	*****	*****	*****
	SKETCH	OF SITE	
SESSION 1	SESSSI	ION 2	SESSION 3

Describe any abnothe survey, includuration.	nde session num	ber, time of	
		Back	

Figure D-3. (Concluded)

for: Calpella (Sessions 1 and 2), Ukiah Airport (Session 3), Ukiah Airport (Session 1), Perry (Sessions 1 and 2), Pier 1 (Sessions 1, 2, and 3), and Pier 2 (Sessions 1, 2, and 3). An example of a GPS station observation log for Pier 2 is shown in Figure D-4.

D-2. Actual Survey Operation

These portions of the GPS station observation log which were not filled out during the planning phase of the survey were filled out during data collection. An example of the GPS station observation log for Pier 2, filled out after data collection, is shown in Figure D-5.

- a. The key to proper data collection is the correct setup of the equipment (tripod, receiver, and power source) and correct antenna height measurements (height of the antenna above the mark).
- b. Figure D-6 shows personnel correctly taking an antenna height measurement over a temporary monument. Figure D-7 illustrates a typical antenna setup with the following equation detailing the antenna height correction.

$$v = \sqrt{(s)^2 - (r)^2}$$
 (D-1)

where

- v = corrected vertical height distance of the antenna center above the mark
- s = slope distance measurement derived from the average of several antenna height measurements made
- r = antenna radius
- c. When measuring the antenna height during this survey, the procedure below was followed in order to ensure an accurate reading:
- (1) The slope distance from the north point of the antenna to the center of the monument was measured to the nearest millimeter (0.001 m). Measurement was also done in non-SI units (inches) to the nearest 1/32 of an inch. This value then was compared to the metric value measured earlier in order to detect blunders.
- (2) Similar measurements were also taken from the south point of the antenna to the center of the monument.

- (3) The resultant north and south slope distances were averaged.
 - (4) Example: (Refer to Figure D-5.)
 - (a) Tripod set up flat on a dock.
- (b) The north side measure up for session 1 = 0.120 m.
- (c) The south side measure up for session 1 = 0.120 m.
- (d) An extra "Check Measurement" was also taken for the measure up for Session 1 and was found to be 0.394 ft.
- (e) As a check: (0.394 ft.) x (1 m/3.281 ft.) = 0.120 m.
- (f) This value was recorded in the GPS station observation log.
- d. Each GPS receiver was operated in direct accordance with the manufacturer's instructions, procedures, and/or guidance.
- e. No problems were encountered during the survey sessions.

D-3. Post-Processing Observation Data

All observation data recorded were downloaded from the receivers to a 5.25-in. floppy disc. The downloading procedures detailed in the manufacturer's operating manuals were strictly adhered to.

- a. Once the observation data were downloaded, preprocessing of data was performed. Preprocessing of data included checking the station names, antenna heights, latitude, longitude, and elevation of the points, as well as applying any required corrections. In general, most GPS processing software requires the antenna slope height be corrected to vertical at some point in the survey, usually during the pre-processing phase. (Consult receiver/ software manufacturer guidelines for specifics.)
- b. The data for the Ukiah project were post-processed using TRIMBLE software, but in general, all post-processing software produces similar results. The

PROJECT NAME OBSERVER LARR	COYOTE DAM	LOCALITY D	KIAH, CA
RECEIVER TRIMB	LAMB A	S/N Zgzo	CRAMENTO DISTRIC
	LE MICROSL	S/N 28/6	
DATA RECORDING	UNIT RECEIVER		
TRIBRACH WILD G	DF ZZ S/N		
******	*****	*********	*****
STATION: NAME	SESSION 1	SESSION 2	SESSION 3
STATION: NAME NUMBER	PIERZ	PIERZ	PIER 2
HOHDER	2002	2002	2002
DAY OF YEAR	1/5	115	1/5
		. / /	
DATE MM DD YY	4/25/89	4/25/89	<u>4/25/89</u>
UTC TIME OF	START STOP	START STOP	START STOP
	04:56 A5:55	06:/0 07:38	START STOP 07:55 09:20
******	~ 	*******	******
	ANTENNA HEIG	HT MEASUREMENTS	
	SESSION 1	SESSION 2	SESSION 3
SLOPE @			
BEGINNING	IN= M	IN=M	IN=M
MI	N = M	MN = M	$MN = \underline{\qquad} M$
SLOPE @			
END _		$ \overline{N}=$ \overline{M}	
M		$\overline{MN} = M$	MN = M
			
MN ADJ TO VERT:	M	M	M
**************		******	
	FIELD PROGRAM SITION REFPO		GRAMMED FIELD EFPOS POSITION
LAT 39-/2-30	37-/2-3		EFPOS POSITION
			<u> </u>
Long <u>/23-/0-3</u> 0	/23-10-	30	-10-30
HT 244.0	つびひ. ハ	. 7	44. A
HT 2 <u>44.0</u>	244-0	<u> </u>	44.0
	<u> </u>		44.0
PDOP <u>3.6</u>	4.8		· · · · · · · · · · · · · · · · · · ·
PDOP 3.6 SVS TO 02.03.06	4.8		· · · · · · · · · · · · · · · · · · ·
PDOP	4.8		· · · · · · · · · · · · · · · · · · ·
PDOP 3.6 SVS TO 02.03.06. FRACK //,/2,/3, LOCAL TIME: SCHEDULED	4.8 09 02,0 14 11,11	03,06,09	03,06,09,11 12,13,14,16
PDOP 3.6 SVS TO 02.03.06. TRACK //,12,/3, LOCAL TIME: SCHEDULED START 2/:55	4.8 09 02,0 14 11,10 ACTUAL SCHED 23:3	2, 13, 14 ULED ACTUAL SC	03,06,09,(/ /2,13,14,16 HEDULED ACTUAL :20
PDOP 3.6 SVS TO 02.03.06. FRACK //,/2,/3, LOCAL TIME: SCHEDULED	4.8 09 02,0 14 11,10 ACTUAL SCHED 23:3 00:3:	ULED ACTUAL SC	03,06,09,(/ /2,13,14,16 HEDULED ACTUAL :20

Figure D-4. GPS station observation log, presurvey (Continued)

	-	PS OF ENGINEER: OGGING SHEET	
*****			**************************************
ANT CABLE LENGTH	SESSION 2 _ <i>100 </i>	SESSION 2	35 FT
POWER SUPPLY	12 V DC	12 V DC	12 V DC.
NEATHER CONDITIONS			
MONUMENT TYPE	"C" (SET IN PIE	R) - SAME	- SAME
EXACT STAMPING	PIER 2 1953	de-	<u> </u>
AGENCY CAST IN DISK	COE	A ('	
	*****	*****	*****
SESSION 1	SKETCH SESSIO	OF SITE ON 2	SESSION 3

	normalities and	or problems ei	ncountered during
*****		********** AGE 2	******
	L	Back	

Figure D-4. (Concluded)

	DA AE BUATURERA						
	PS OF ENGINEERS						
	GPS DATA LOGGING SHEET ***********************************						
PROJECT NAME COYOTE DAM	LOCALITY <u>UKIAH, CA</u> GENCY/FIRM <u>COE</u> SACRAHENTO DISTRICT						
OBSERVER <u>LARRY LAMB</u> AG	ENCY/FIRM <u>COE SACRAMENTO DISTR</u> ICT						
RECEIVER TRIMBLE 40005L	RECEIVER TRIMBLE 40005L S/N 2820400223 ANTENNA TRIMBLE WERD SL S/N 2816400224 DATA RECORDING UNIT RECEIVER S/N 2820400224 TRIBRACH WILD GDF 22 S/N N/4 LAST CALIBRATED: 4/24/89						
ANTENNA TRIMBLE FURA SL	S/N 2816 A 00224						
DATA RECORDING UNIT RECEIVER	S/N 2820400224						
TRIBRACH WILD GOF 22 S/N N/	A LAST CALIBRATED: 4/24/89						
**********	*********						
SESSION 1	SESSION 2 SESSION 3						
STATION: NAME PIER 2	PIER 2 PIER 2						
NUMBER ZOOZ	2002 2002						
DAY OF YEAR 1/5	115 115						
							
DATE MM DD YY 4/25/89	4/25/89 4/25/89						
7/20/4/	11-4-4						
UTC TIME OF START STOP	START STOP START STOP						
	06:/0 07:38 07:55 09:20						
******************************	**************************************						
	HT MEASUREMENTS						
ANTENNA REIGH	T MEASUREMENTS SESSION 2 SESSION 3 O.11C O.116 O.116 O.123 O.124 O.124 4 % IN= 0.116 M 4 % IN= 0.124 M MN = 0.116 M MN = 0.1238 M						
SESSION I	5E5510N 2 5E5510N 3						
SLOPE @ 0./20 0./20 0.120	0.116 0.116 0.123 0.124 0.124						
BEGINNING 4/3/6 IN=0.121 M	4 9/6 IN=0.116 M 414/6 IN=0.124 M						
MN = O.120 M	$\overline{MN} = 0.76$ $\overline{MN} = 0.738$ \overline{M}						
1111 4127 1147	1187 1191 1191 11187 11147 11147						
SLOPE @ #//6 71//6 47/16	4 yil 4 1/16 4 1/6 7 1/1 T 1/16 7/16						
END 0.120 IN= 4 3/4 M	0.116 IN=4 1/16 M 0.123 IN= 7 1/16 M						
SLOPE @ $\frac{4^{1}/6}{0.120}$ IN= $\frac{4^{12}/6}{10}$ M	0.16 IN=4 16 M 0.123 IN= 4 16 M MN = 0.16 M MN = 0.1230 M						
MN ADJ TO VERT: 0./20 M	0.1/6 M 0.1234 M						
*********	*************						
PROGRAMMED FIELD PROGRAMM							
REFPOS POSITION REFPOS	S POSITION REFPOS POSITION						
LAT 39-12-30 39-12-22.64 39-12-30	0 39-12-22.48 39-12-30 39-12-22.81						
LONG /23-10-30 /23-10-23 42 /23-/0-3	30 / <u>23-10-33</u> .20 / <u>23-10-3</u> 0 / <u>23-10-33</u> .62						
(<u>-2 /- v</u>) (<u>-2 /-)</u> (<u>-2 /- v</u>)							
HT 244.0 210.6 244.0	199.8 244.6 222.8						
<u>2/1-0</u> <u>0/10</u>	7777						
PDOP 3.6 - 4.8							
PDOP 3.6 4.8							
2V2 M0 A2 A2 A2 -2 -2 -	2 4/ 44						
MDACK 427	03,06,09 <u>03,06,09,11</u> 2,13,14 12,13,14,16						
TRACK 11, 12, 13, 14 11, 12	4/5,14 12/13,17/16						
LOCAL							
	JLED ACTUAL SCHEDULED ACTUAL						
START 21:55 21:56 23:38	23:10 01:20 00:55						
START 21:55 21:56 23:38 STOP 22:55 22:55 20:38	23:10 01:20 00:55 00:38 02:20 02:20						
*************	********						
PA	GE 1						
a.	Front						

Figure D-5. GPS station observation log, postsurvey (Continued)

	U.S. ARMY CORPS		ERS
ما و الله والله			*****
*****	SESSION 1	SESSION 2	SESSION 3
ANT CABLE LENGTH	100 Ft	100 ft	<u>35 f+</u>
POWER SUPPLY	12 V DC	124 DC	12 V DC
WEATHER CONDITIONS	CLEAR, COOL	CLEAR COOL	CLEAR, COOL
MONUMENT TYPE	"C" (SET IN PIER)	- SAME	SAME
EXACT STAMPING	PIER 2 1953	A	· · · · · · · · · · · · · · · · · · ·
AGENCY CAST	COE	<u>* "</u>	<u>"</u>
IN DISK	*****	*****	******
	SKETCH		
SESSION 1	SESSION		SESSION 3
RUSSIAN RIVER A PIER Z	SAME		SAM E
Describe any abrithe survey, includeration. THE ANTENNA WITH NO TANTENNA HE GROUND PLA	normalities and/elude session number was mounted report used, to BRAS	or problems ber, time of DIRECTLY EASUR ED S DISK.	
	b .	Back	

Figure D-5. (Concluded)

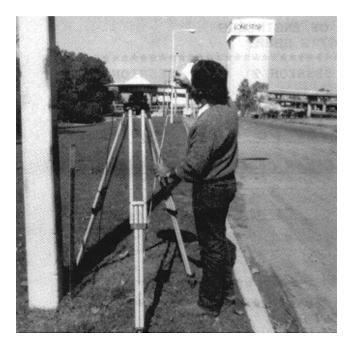


Figure D-6. Antenna height measurement

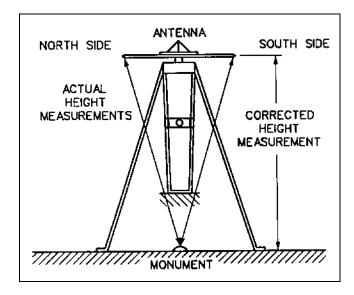


Figure D-7. Diagram of antenna setup

observation data were processed in accordance with manufacturer's guidelines. (See Chapter 10 for further discussion on post-processing.)

- (1) An examination of the results reveals the following, which are produced in one form or another in other manufacturer's solution file formats:
 - (a) Listing of the file name.

- (b) Types of solutions (single, double, or triple difference).
- (c) Satellite availability during the survey for each station occupied.
 - (d) Ephemeris file used for solution formulation.
 - (e) Type of satellite selection (manual or automatic).
 - (f) Elevation mask.
 - (g) Minimum number of satellites used.
- (h) Meteorological data (pressure, temperature, humidity).
 - (i) Session time (date, time).
 - (j) Data logging time (start, stop).
 - (k) Station information:
 - Location (latitude, longitude)
 - · Receiver serial number used
 - · Antenna serial number used
 - ID number
 - Antenna height
 - (1) RMS.
 - (m) Solution files:
 - ∆x, ∆y, ∆z between stations
 - Slope distance between stations
 - ∆latitude, ∆longitude between stations
 - Distance between stations
 - Aheight
 - (n) Epoch intervals.
 - (o) Number of epochs.
- (2) The triple difference, double difference float, and double difference fix TRIMBLE solutions of the baseline reductions for 2014->2002 are shown annotated with the above conventions (a o) provided as an explanation.
- c. In general, all GPS manufacturer data reduction software programs produce a summary of results once data have been reduced and a baseline formulated.

- d. The listing of the baseline formulations for line 2014 to 2002 follows in Figure D-8, as reproduced from the TRIMBLE Navigation TRIMVEC solution file.
- e. Although the TRIMBLE summary solution file does specify that the integers were found, the RMS is OK, and FIXED solution is recommended, an analysis of the output prior to this conclusion in accordance with Chapter 10 would have revealed the following:
- (1) With a baseline distance of 7,000 m for the formulated baseline (baseline 1402) and from Table 10-1, the RMS must be less than [(0.02+(0.004*d))]. Using the equation [(0.02+(0.004/d))] from Table 10-1 with a d (distance) equal to 7 km, the equation is [(0.02+(0.004*7))] and the RMS is approximately equal to 0.048. Therefore, the RMS is acceptable.
- (2) With a baseline distance of 7,000 m for the formulated baseline (baseline 1,402) and from Table 10-1, the quality factor ratio must be more than 3. The fixed solution factor from the summary solution file is 18.9. Therefore, the fixed solution quality factor is acceptable.
- (3) From Table 10-1, with a baseline length of 7 km for baseline 1402 (between 0 and 20 km), an acceptable RMS (small), an acceptable quality factor ratio (large), and an integer solution, the fixed solution should be acceptable.
- f. All other formulated baselines for this survey were found to be acceptable.

D-4. Loop Closure

An approximate loop closure was done by following the procedures detailed in Chapter 10. The resulting calculations would proceed as shown in the following computation:

- a. Follow Figure D-9, holding 2013 as the starting point.
- b. Formulate a table similar to Table 10-3 (see page D-25), where all values are taken from the GPS post-processed baseline formulations:
- c. Sum up the $\triangle x$, $\triangle y$, $\triangle z$, and distance components:

$$\begin{split} \Sigma \Delta x \ components &= \Delta x (2013 \text{--} 2014) + \Delta x (2014 \text{--} 2002) \\ &+ \Delta x (2002 \text{--} 2006) + \Delta x (2006 \text{--} 2001) \\ &+ \Delta x (2001 \text{--} 2013) \end{split}$$

$$\begin{split} \Sigma \triangle y \ components &= \triangle y (2013 \text{->} 2014) + \triangle y (2014 \text{->} 2002) \\ &+ \triangle y (2002 \text{->} 2006) + \triangle y (2006 \text{->} 2001) \\ &+ \triangle y (2001 \text{->} 2013) \\ &= \text{-7,891.019} + 2,554.018 \\ &+ (\text{-748.319}) + 1,441.548 + 4,643.775 \\ &= 0.003 \end{split}$$

$$\sum \Delta z$$
 components = $\Delta z(2013 - 2014) + \Delta z(2014 - 2002)$
+ $\Delta z(2002 - 2006) + \Delta z(2006 - 2001)$
+ $\Delta z(2001 - 2013)$
= -10,410.673 + 5,296.798
+ (-16.709) + 908.280 + 4,222.288

$$\Sigma Distances = (2013->2014) + (2014->2002) + (2002-2006) + (2006->2001) + (2001->2013) = 13,490.362 + 7,000.823 + 1,212.035 + 1,829.593 + 6,317.297 = 29,850.110$$

d. From Equation 10-1:

$$M = \sqrt{(0.009)^2 + (0.003)^2 + (-0.016)^2}$$
 (D-2)

$$= \sqrt{(0.000081) + (0.000009) + (0.000256)}$$
 (D-3)

= 0.018601075 or 0.0186

Therefore, misclosure is approximately 0.0186 in., 29,850.110 m, or 1 part in 1,600,000.

D-5. Final Adjustment

The program used for final adjustment of the Ukiah survey was the GEOLAB program. For an in-depth technical discussion on GEOLAB, refer to the literature accompanying the GEOLAB software package. The following discussion on the GEOLAB adjustment of the Ukiah survey highlights some of the criteria used in the adjustment of a horizontal survey.

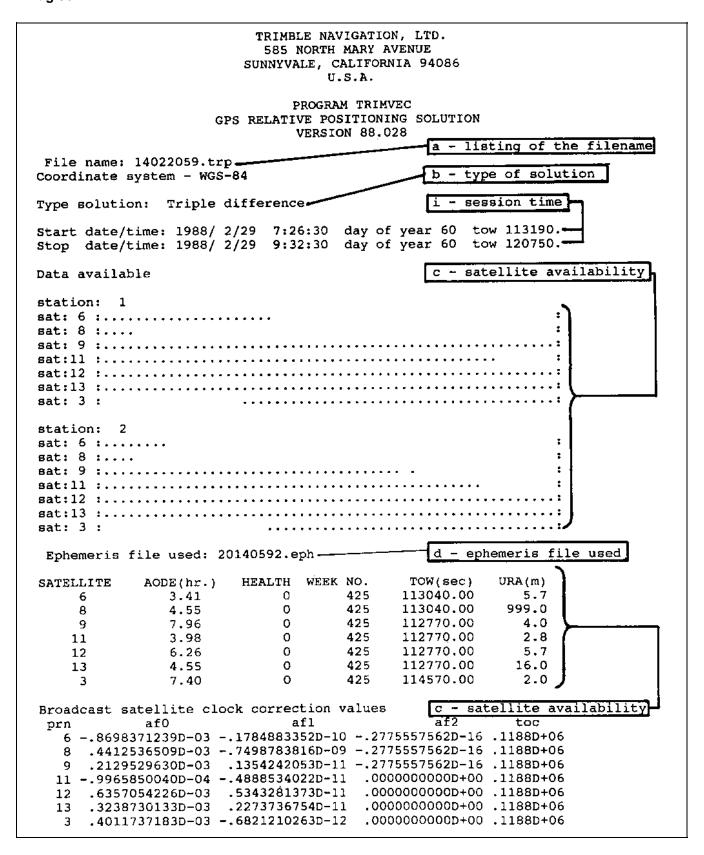


Figure D-8. TRIMBLE solution file (Ukiah) (Sheet 1 of 13)

```
Message file for station 1
.........
Station ID: 2014 Session #: 059-2 Feb. 29, 1988 07:24
Reference Position - HIGH ACCURACY:
Lat.= 39:07'57.401"N Long.=123:12'14.788"W Height=190.2 [meters]
Antenna height = 1.4387 [meters] (entered in the field in feet)
Receiver serial # = 4604
Antenna serial # = 110 (entered in the office)
Survey schedule mode
                     = AUTOMATIC
                                               k - station information
Data-logging start time = 07:26.
Data-logging stop time = 09:33-
                                🖣j - data logging time
                                                       c - satellite
                                                            availability
             Ch1
                   Ch2
                         Ch3
                               Ch4
                                     Ch5
                                          Ch6
                                                      Ch8
       Ch0
                                                Ch7
                                                            Ch9
                    8
                          9
                                11
                                     12
                                           13
                                                 0
                                                        0
                                                             0
SVR
        3
              - 6
# meas
       379
             170
                    28
                         506
                               445
                                     506
                                          506
                                                  0
                                                        0
                                                              0
                    28
                         506
                               445
                                     506
                                          506
                                                        0
# cont 379
             170
                                                  0
                                                              O
                          SELECTION e - type of satellite
[degrees] Minimum # of SVs = 4 selection
g - minimum # of satellites
SV Selection mode = MANUAL SELECTION -
                = 20
Elevation mask
4 SV Position
                Best PDOP Position [ 3.1]
                                            Mean Position [497]
                 39:07'57.17388" N
Latitude:
                                             39:07'57.14899" N
                                            123:12'14.64029" W
                123:12'14.47260" W
Longitude:
Height [m]:
                          169.0
                                                      170.3
3 SV Position
                Best PDOP Position [ 2.5]
                                            Mean Position [9]
                 39:07'57.62620" N
                                            39:07'57.51783" N
Latitude:
                123:12'14.95426" N
                                            123:12'14.88427" N
Longitude:
 Origin of station 1 coordinates: Best C/A code tracking solution
  STATION (mark) 1
                                               k - station information
input data file 1 : 20140592.dat
antenna height (m)
                   1.378
                                      1010.0
                  pressure(mb)
met values used:
                                               h - meteorological data
                  temperature(deg C)
                                        20.0
                                        50.0
                  relative humidity(%)
                        lat (dms) N
                                        39
                                               7 57.13720
  x (m)
         -2713023.277
         -4145293.358
                        elon (dms) E
                                        236
                                              47 45.39187
  y (m)
                                       123
          4003847.775
                        wlon (dms) W
                                              12 14.60813
  z (m)
                                        168.8847
                        ht (m)
Message file for station 2
 Station ID: 2002 Session #: 059-2 Feb 29, 1988 07:21
Reference Position - LOW ACCURACY:
Lat. = 39:12'30.000"N Long. = 123:10'30.000"W Height = 244.0 [meters]
Antenna height = 0.1201 [meters] (entered in the field in feet)
Receiver serial # = 4604 ---
                                               k - station information
Antenna serial # = 108 (entered in the office)
Survey schedule mode
                      = AUTOMATIC
Data-logging start time = 07:23 --
                                                 - data logging time
Data-logging stop time = 09:32
```

Figure D-8. (Sheet 2 of 13)

```
Ch3
                              Ch4
                                   Ch5
                                         Ch6
                                              Ch7
                                                    Ch8
                                                          Ch9
                  Ch2
       Ch0
             Chl
                                         13
                                               0
                                                      0
                                                            0
             6
                   8
                        9
                              11
                                   12
        3
SVs
       356
                        392
                              457
                                   515
                                         515
                                                0
                                                      0
                                                            0
# meas
              78
                    41
                                                      0
                                                            0
# cont 356
              65
                    41
                        381
                              457
                                   515
                                         515
                                                0
                                          e - type of satellite
SV Selection mode = MANUAL SELECTION-
Elevation mask = 20 [degrees] Minimum # of SVs = 4 selection
                  f - elevation mask g - minimum # of satellite
                                           Mean Position [358] used
                Best PDOP Position [ 3.5]
4 SV Position
                                           39:11'36.67782" N
                39:11'36.62852" N
Latitude:
               123:11'00.34360" W
                                           123:11'00.44659" W
Longitude:
                         251.8
                                                    247.9
3 SV Position Best PDOP Position [ 2.5] Mean Position [157]
               39:11'36.93995" N
Latitude:
                                           39:11'36.76322" N
                                           123:11'00.69634" W
               123:11'00.75300" N
Longitude:
 STATION (mark) 2-
input data fle 1 : 20020592.dat ---
                                             k - station information
antenna height (m) .120-
                                     1010.0
                pressure(mb)
met values used:
                                              h - meteorological data
                  temperature(deg C)
                                     20.0
                  relative humidity(%)
                                       50.0
                       lat (dms) N 39
elon (dms) E 236
                                       39
                                             7 36.66538
 x (m) -2709224.288
                                             48
                                                 59.56686
 y (m) -4142739.316
                        wlon (dms) W 123
                                            11
                                                 .43314
         4009144.597
  z (m)
                                       244.2261
                        ht (m)
slope distance (m) 7000.8406 sigma (m)
normal section azimuth (dms) 14 43 50.71
                            0 35 6.35
vertical angle (dms)
                    up(m) 1780.060 6770.280
                                                  71.490 m - solution file
east(m) north(m)
Delta lat(dms) 0
Delta lon(dms) 0
                    3 39.52817
Delta lon(dms)
                    1
                        14.17498
             75.3413
Delta ht(m)
Vector covariance matrix (m**2) :
                                                          dz
                      dх
    dx .293867564477D-02
    dy -.241348364603D-02
                         .463858449191D-02
    dz -.669428866095D-03 -.252458261144D-03 .689895896357D-03
 correlations
          dх
                 dy
                       dz
    dx 1.000
    dy -.654 1.000
dz -.470 -.141 1.000
                                     Sigma
                     Solution
                     3798.989
                                      .054
    dx (m)
                                     .068
                    2554.042
    dy (m)
    dz (m)
                    5296.822
                                      .026
Interval between epochs (sec)
                              150 ___
Epoch increment 5 ----
                                               n - epoch intervals
Number of measurements used in solution 168
                                               o - number of epochs
Number of measurements rejected
```

Figure D-8. (Sheet 3 of 13)

```
1 - RMS
RMS (cycles)
                      .033 ———
                           15.0
Elevation mask (deg)
                        3.5
Edit multiplier
Modified Hopfield troposphere model used
Best tracking C/A code positions
                                                m - solution files
Station 1
Pdop
            3.1
                                         39 7 57.13720
           -2713023.862
                           lat (dms) N
 x (m)
                                                45.39187
                           elon (dms) E 236 47
          -4145294.253
 y (m)
                          wlon (dms) W 123 12 14.60813
            4003848.645
 z (m)
                                          170,2629
                           ht (m)
                    .43266808D-03
clock offset(s)
                    -.11042348D-08
freq offset(s/s)
Code calibration(m) Carrier calibration(m)
                                       .0012
              .2520
1 - 2
                                      -.0006
                .0552
1 -
    3
               -.0249
                                      -.0007
1 -
    4
               .9292
                                      -.0008
1 -
    5
               -.2124
                                      -.0010
1 -
    6
              -.0181
                                      -.0005
    7
1 -
1 - 8
                                      -.0009
              -.1875
              -.1875
                                      -.0012
1 - 9
                                      -.0014
1 - 10
               1.0630
                                                 m - solution files
Station 2
          2.5
Pdop
          -2709227.033
                           lat (dms) N
                                          39 11
                                                 37.11338
 x (m)
                           elon (dms) E
          -4142726.880
                                         236 48 59.18749
 y (m)
                                         123 11
                                                   .81251
           4009155.162
                           wlon (dms) W
  2 (m)
                                          244.0000
                           ht (m)
                      .88584966D-03
clock offset(s)
                     .58827784D-09
freq offset(s/s)
 Code calibration(m) Carrier calibration(m)
              .2021
                                       .0007
1 - 2
1 -
                                      -.0011
               -.3682
     3
               -.4199
                                      -.0010
1 -
     4
1 -
    5
               -.5342
                                      -.0013
                                      -.0011
1 -
    6
               -.5234
                                      -.0002
1 -
    7
              -.2754
              -.6040
                                      -.0014
1 -
    8
1 - 9
              -.8003
                                      -.0020
1 - 10
              -.6953
                                      -.0017
```

Figure D-8. (Sheet 4 of 13)

TRIMBLE NAVIGATION, LTD.	
585 NORTH MARY AVENUE	
SUNNYVALE, CALIFORNIA 94086	
U.S.A.	
PROGRAM TRIMVEC	
GPS RELATIVE POSITIONING SOLUTI	ON
VERSION 88.028	11-11
File name: 14022059.flt	listing of filename
	type of solution
Coordinate system - MGS-044	type of solution
Type solution: Triple difference	session time
Type Boldcion: Illpic dillerence	CIME
Start date/time: 1988/ 2/29 7:26:30 day of year 60	tow 113190.
Start date/time: 1988/ 2/29 7:26:30 day of year 60 Stop date/time: 1988/ 2/29 9:32:30 day of year 60	tow 120750.
Data available c - c	satellite availability
<u></u>	
station: 1	`
sat: 6 :	:
sat: 8 :	; <u> </u>
sat: 9 :	
sat:11 :	
Bat:12 :	
sat:13 :	
sat: 3:	
-t-t-1 D	
station: 2 sat: 6 :	. (
Bat: 8 :	:
Bat: 9 :	: 1
Bat:11 :	. : 1
sat:12 :	
gat:13 :	
sat: 3:	.
<u> </u>	
Ephemeris file used: 20140592.eph d - d	ephemeris file used
SATELLITE AODE(hr.) HEALTH WEEK NO. TOW(sec	, , , ,
6 3.41 0 425 113040.06	
8 4.55 0 425 113040.00	
9 7.96 0 425 112770.09	
11 3.98 0 425 112770.09	
12 6.26 0 425 112770.00	- · · · · · · · · · · · · · · · · · · ·
13 4.55 0 425 112770.00	
3 7.40 0 425 114570.00	0 2.0
Broadcast satellite clock correction values c -	satellite availability
	toc
<pre>prn af0 af1 af2 68698371239D=031784883352D=102775557562D=</pre>	
8 .4412536509D-037498783816D-092775557562D-	
9 .2129529630D-03 .1354242053D-112775557562D-	
119965850040D-044888534022D-11 .0000000000D+	
12 .6357054226D-03 .5343281373D-11 .0000000000D+	
13 .3238730133D-03 .2273736754D-11 .0000000000D+	
3 .4011737183D-036821210263D-12 .0000000000D+	

Figure D-8. (Sheet 5 of 13)

```
Message file for station 1
 Station ID: 2014 Session #: 059-2 Feb. 29, 1988 07:24
Reference Position - HIGH ACCURACY:
Lat.= 39:07'57.401"N Long.=123:12'14.788"W Height=190.2 [meters]
Antenna height = 1.4387 [meters] (entered in the field in feet)
Receiver serial # = 4604
Antenna serial # = 110 (entered in the office)
                                           k - station information
                    = AUTOMATIC
Survey schedule mode
Data-logging start time = 07:26,
Data-logging stop time = 09:33 - j - data logging time
                                                     c - satellite
                                                        availability
                             Ch4
                                       Ch6
                                            Ch7
                       Ch3
                                  Ch5
                                                  Ch8
                                                        Ch9
       Ch0
            Ch1
                  Ch2
                                  12
                  8
                       9
                             11
                                       13
                                             0
                                                    0
                                                         0
SVs
       3
            6
                                                         0
                   28
                       506
                             445
                                  506
                                       506
                                              0
                                                    0
# meas 379
            170
            170
                   28
                       506
                             445
                                  506
                                       506
                                              0
                                                    0
# cont 379
SV Selection mode = MANUAL SELECTION -
                                           e -type of satellite
Elevation mask = 20 [degrees] Minimum # of SVs = 4 selection
                                         g - minimum # of satellite
                  f - elevation mask
                                         Mean Position [497]
                                                                used
               Best PDOP Position [ 3.1]
4 SV Position
                                         39:07'57.14899" N
               39:07'57.17388" N
Latitude:
               123:12'14.47260" W
                                         123:12'14.64029" W
Longitude:
                                                  170.3
                        169.0
Height [m]:
3 SV Position
               Best PDOP Position [ 2.5] Mean Position [9]
               39:07'57.62620" N
                                         39:07'57.51783" N
Latitude:
                                         123"12'14.88427" N
               123:12'14.95426" N
Longitude:
 Origin of station 1 coordinates: Best C/A code tracking solution
  STATION (mark) 1
                                           k - station information
input data file 1 : 20140592.dat
 antenna height (m) 1.378
                 pressure(mb)
                                    1010.0
met values used:
                                          h - meteorological data
                                      20.0
                 temperature(deg C)
                                      50.0
                 relative humidity(%)
                                      39
                                            7 57.13720
                      lat (dms) N
        -2713023.277
 x (m)
        -4145293.358
                      elon (dms) E
                                     236
                                           47
                                              45.39187
 y (m)
                      wlon (dms) W
                                     123
                                           12
                                              14.60813
         4003847.775
 z (m)
                                     168.8847
                      ht (m)
 Message file for station 2
 ...............
Station ID: 2002 Session #: 059-2 Feb 29, 1988 07:21
Reference Position - LOW ACCURACY:
Lat.= 39:12'30.000"N Long.=123:10'30.000"W Height=244.0 [meters]
Antenna height = 0.1201 [meters] (entered in the field in feet)
Receiver serial # = 4606----
                                           k - station information
Antenna serial # = 108 (entered in the office)
Survey schedule mode = AUTOMATIC
                                           j - data logging time
Data-logging start time = 07:23-
Data-logging stop time = 09:32-
```

Figure D-8. (Sheet 6 of 13)

```
Ch1
                  Ch2
                        Ch3
                              Ch4
                                   Ch5
                                         Ch6
                                              Ch7
                                                    Ch8
                                                          Ch9
       Ch0
                              11
                                   12
                                         13
                                              0
                                                     0
                                                            0
SVs
        - 3
             6
                   8
                        9
                                                            0
       356
              78
                   41
                        392
                              457
                                   515
                                         515
                                                0
                                                      0
# meas
                                                            0
      356
              65
                   41
                        381
                              457
                                   515
                                         515
                                                0
                                                      0
# cont
SV Selection mode = MANUAL SELECTION e - type of satellite selection
                        [degrees] Minimum # of SVs = 4
Elevation mask = 20
                     f - elevation mask g - minimum # of satellite
                Best PDOP Position [ 3.5]
                                          Mean Position [358]
4 SV Position
                                           39:11'36.67782" N
                39:11'36.62852" N
Latitude:
                                           123:11'00.44659" W
                123:11'00.34360" W
Longitude:
                                                    247.9
Height [m]:
                        251.8
                      k - station information
3 SV Position Best PDOP Position [ 2.5] Mean Position [157]
                39:11'36.93995" N
                                           39:11'36.76322" N
Latitude:
                                           123:11'00.69634" W
Longitude:
              123:11'00.75300" W
 STATION (mark) 2-
input data file 1 : 20020592.dat ---
                                             k - station information
antenna height (m) .120----
met values used: pressure(mb)
                                    1010.0
                                             h - meteorological data
                 temperature(deg C) 20.0
                                      50.0
                 relative humidity(%)
                                      39
                                            11
                                                 36.66472
 x (m) -2709224.255
                       lat (dms) N
                        elon (dms) E 236
                                             48
                                                 59.56932
 y (m)
        -4142739.375
                        wlon (dms) W 123
                                            11
                                                   .43068
         4009144.596
 z (m)
                        ht (m)
                                       244.2494
                   7000.8363
slope distance (m)
                                sigma (m)
                                            .036
normal section azimuth (dms) 14 43 52.54
vertical angle (dms)
                            0 35 7.03
east(m) north(m) up(m) 1780.120
                                                  71.514 m - solution file
                                       6770.360
Delta lat(dms) 0 3 39.52751
Delta lon(dms) 0 1 14.17745
               75.3647
Delta ht(m)
Vector covariance matrix (m**2) :
                     dх
   dx .441035064208D-02
   dy -.450901919640D-02 .575064973739D-02
   dz -.118686476647D-02 .787301206000D-03 .689846755147D-03
correlations:
                dy dz trop bias1 bias2 bias3 bias4 bias5 bias6
          dx
bias7
   dx 1.000
   dy -.895 1.000
   dz -.680 .395 1.000
 trop .000 .000 .000 1.000 ciasl .000 .000 .000 .000 .000
 biasl
                             .000 1.000
                        .000
      .587 -.667 -.394
 bias2
                              .000
                        .000
       .925 -.836 -.683
                                   .000 1.000
 bias3
                             .000
       .884 -.865 -.679
                                   .000 .000 1.000
                        .000
 bias4
                        .000
                                   .000 .000 .000 1.000
                             .000
 bias5 .972 -.919 -.675
                        .000
                             .000
                                   .000 .000
                                               .000 .000 1.000
 bias6 .969 -.912 -.687
      .000.000.000.000
                                   .000 .000 .000 .000
 bias7
1.000
```

Figure D-8. (Sheet 7 of 13)

```
Solution
                                 Sigma
                                       Sensitivity to 10 meter error
                                            in station 1 coordinates
                   3799.022
                                  .066
    dx (m)
                                            9.996
                                                       .001
                                                                .002
                   2553.984
                                  .076
                                             .003
                                                      9.998
                                                               -.006
    dy (m)
                                  .026
    dz (m)
                   5296.821
                                             .004
                                                       .002
                                                               9.999
                       .000
                                  .000
                                             .000
                                                       .000
  trop (%)
                                                                .000
                       .000
                                  .000
bias 1 (cycle)
                                            .000
                                                       .000
                                                                .000
bias 2 (cycle)
                       .098
                                  .272
                                            -.025
                                                       .005
                                                                .015
bias 3 (cycle)
                                  .271
                      -.000
                                            -.020
                                                       .004
                                                                .017
                                                       .008
bias 4 (cycle)
                       .025
                                  .294
                                            -.028
                                                                .019
                       .112
                                            -.039
bias 5 (cycle)
                                  .572
                                                       .012
                                                                .038
bias 6 (cycle)
                       .086
                                 .537
                                                       .012
                                            -.038
                                                                .035
bias 7 (cycle)
                                             .000
                                                                .000
                       .000
                                 .212
                                                       .000
 Interval between epochs (sec)
                                120
 Epoch increment
                     4
 Number of measurements used in solution
                                            167
 Number of measurements rejected
                                             50
                  .020
 RMS (cycles)
                                                 1 - RMS
 Elevation mask (deg)
                         15.0
 Edit multiplier
                          3.5
 Modified Hopfield troposphere model used
Best tracking C/A code positions
                                                 m - solution files
Station 1
Pdop
            3.1
           -2713023.862
                                           39 7
  x (m)
                          lat (dms)
                                      N
                                                 57.13720
  y (m)
           -4145294.253
                          elon (dms) E 236 47 45.39187
            4003848.645
                                          123 12 14.60813
  z (m)
                          wlon (dms)
                                      W
                          ht (m)
                                           170.2629
                      .43266808D-03
clock offset(s)
                     -.11042348D-08
freq offset(s/s)
Code calibration(m) Carrier calibration(m)
1 - 2
                .2520
                                         .0012
1 - 3
                .0552
                                        -.0006
1 - 4
               -.0249
                                        -.0007
1 - 5
                .9292
                                        -.0008
1 - 6
               -.2124
                                        -.0010
1 - 7
               -.0181
                                        .0005
               -.1875
1 - 8
                                        -.0009
1 - 9
               -.1875
                                        -.0012
1 - 10
               1.0630
                                        -.0014
                                                      solution files
Station 2
                                                 m -
Pdop
           2.5
x (m)
          -2709227.033
                           lat
                                  (dms) N
                                            39
                                                  11
                                                       37.11338
          -4142726.880
                           elon (dms) E 236
                                                  48
                                                       59.18749
y (m)
          4009155.162
                           wlon (dms)
                                         W
                                            123
                                                  11
                                                         .81251
2 (m)
                           ht (m)
                                             244,0000
clock offset(s)
                      .88584966D~03
freq offset(s/s)
                      .58827784D-09
 Code calibration(m)
                      Carrier calibration(m)
1 - 2
               .2021
                                        .0007
1 -
     3
               -.3682
                                        -.0011
1 - 4
                                        -.0010
               -.4199
1 -
               -.5342
     5
                                        -.0013
1 - 6
               -.5234
                                        -.0011
1 -
               -.2754
                                        -.0002
    7
1 - 8
               -.6040
                                        -.0014
               -.8003
                                        -.0020
1 - 9
               -.6953
1 - 10
                                       -.0017
```

Figure D-8. (Sheet 8 of 13)

TRIMBLE NAVIGATION	I, LTD.
585 NORTH MARY AV	ENUE
SUNNYVALE, CALIFORNI	IA 94086
U.S.A.	
PROGRAM TRIMVE	ec
GPS RELATIVE POSITIONIN	· -
VERSION 88.028	
VERSION 60.020	
File name: 14022059.fix	a - listing of the filename
Coordinate system - WGS-84	b - type of solution
Coordinate System - Mos-64	b - type of solution
Muna calubian. Daubla dissansan	(
Type solution: Double difference	i - sessiontime
# 1 1 1 1 1 1 1000 1 0 100 H 05 DD 1 F	
Start date/time: 1988/ 2/29 7:26:30 day of	year 60 tow 113190
Stop date/time: 1988/ 2/29 9:32:30 day of	year 60 tow 120750.→
Data available	c - satellite availability
	·
station: 1	`
sat: 6 :	:
sat: 8 :	:
<pre>sat: 9 :</pre>	
sat:11 :	
sat:12 :	
sat:13 :	
sat: 3:	1
station: 2	
sat: 6 :	.
Bat: 8 :	: 1
gat: 9 :	: I
sat:11:	• •
sat:12 :	• • •
sat:13:	
sat: 3:	••••••
Dahanania 611	
Ephemeris file used: 20140592.eph	d - ephemeris file used
CAMBITIME ACRE/h- \ USALAU MESU NO	MONTAGE TIPE (N.)
SATELLITE AODE(hr.) HEALTH WEEK NO.	TOW(SEC) URA(M)
	113040.00 5.7
	113040.00 999.0
	112770.00 4.0
	112770.00 2.8
	112770.00 5.7
	112770.00 16.0
3 7.40 0 425	114570.00 2.0
Broadcast satellite clock correction values	c - satellite availability
prn af0 af1	af2 toc
68698371239D-031784883352D-102775	
8 .4412536509D-037498783816D-092775	
9 .2129529630D-03 .1354242053D-112775	557562D-16 .1188D+06
119965850040D-044888534022D-11 .0000	000000D+00 .1188D+06
	000000D+00 .1188D+06
	000000D+00 .1188D+06
	00000D+00 .1188D+06
	= ++ + +

Figure D-8. (Sheet 9 of 13)

```
Message file for station 1
 Station ID: 2014 Session #: 059-2 Feb. 29, 1988 07:24
Reference Position - HIGH ACCURACY:
Lat.= 39:07'57.401"N Long.=123:12'14.788"W Height=190.2 [meters]
Antenna height = 1.4387 [meters] (entered in the field of feet)
Receiver serial # = 4604
Antenna serial # = 110 (entered in the office)
                                            k - station information
Survey schedule mode
                    = AUTOMATIC
Data-logging start time = 07:26
Data-logging stop time = 09:33
                                                     c - satellite
                              j - data logging time
                                                        availailabilt
                  Ch2
                       Ch3
                             Ch4
                                  Ch5
                                        Ch6
                                             Ch7
                                                  Ch8
                                                        Ch9
       ChO
            Chl
                                                          0 ,
                                              0
                                                    0
        3
             6
                   8
                        9
                             11
                                  12
                                        13
SVs
                       506
                                        506
                                                    0
                                                          0
            170
                             445
                                               O
                   28
                                  506
# meas
       379
                       506
                             445
                                  506
                                        506
                                               0
                                                    0
                                                          0
            170
                   28
# cont 379
                                           e - type of satellite
SV Selection mode = MANUAL SELECTION-
                     [degrees] Minimum # of SVs = 4 selection
Elevation mask
              = 20
                    f - elevation mask
                                          g - minimum # of satellite
                                         Mean Position [497]
               Best PDOP Position [ 3.1]
                                                                used
4 SV Position
               39:07'57.17388" N
                                         39:07'57.14899" N
Latitude:
                                         123:12'14.64029" W
               123:12'14.47260"W
Longitude:
                        169.0
                                                   170.3
Height [m]:
                                        Mean Position [9]
              Best PDOP Position [ 2.5]
3 SV Position
               39:07'57.62620" N
                                          39:07'57.51783" N
Latitude:
              123:12'14.95426" N
                                        123"12'14.88427" N
Longitude:
 Origin of station 1 coordinates: Best C/A code tracking solution
  STATION (mark) 1
                                            k - station information
input data file 1: 20140592.dat
antenna height (m) 1.378
                                    1010.0
                 pressure(mb)
met values used:
                                      20.0 h - meteorological data
                 temperature(deg C)
                 relative humidity(%)
                                      50.0
        -2713023.277
                       lat (dms) N
                                      39
                                           7
                                                57.13720
x (m)
y (m)
                       elon (dms) E
                                     236
                                           47
                                                45.39187
        -4145293.358
                                     123
                                           12
                      wlon (dms)
                                 W
                                                14.60813
z (m)
         4003847.775
                                      168.8847
                      ht (m)
Message file for station 2
 Station ID: 2002 Session #: 059-2 Feb 29, 1988 07:21
Reference Position - LOW ACCURACY:
Lat. = 39:12'30.000"N Long. = 123:10'30.000"W Height = 244.0 [meters]
Antenna height = 0.1201 [meters] (entered in the field in feet)
Receiver serial # = 4606----
                                           k - station information
Antenna serial # = 108 (entered in the office)
                   = AUTOMATIC
Survey schedule mode
Data-logging start time = 07:23-
                                            j - data logging time
Data-logging stop time = 09:32-
```

Figure D-8. (Sheet 10 of 13)

```
Ch5
                                         Ch6
                                               Ch7
                                                    Ch8
        Ch0
              Ch1
                   Ch2
                         Ch3
                              Ch4
                                                          Ch9
                                    12
                                         13
                                               0
                                                      0
SVB
         3
               6
                    8
                         9
                              11
                                                            O
                                    515
                                         515
                                                 0
                                                      0
                                                            0
                              457
              78
                    41
                         392
# meas
        356
               65
                    41
                         381
                              457
                                    515
                                         515
                                                 0
                                                      ۵
                                                            0
        356
# cont
[degrees] Mini
f - elevation mask
                Best PDOP Position [ 3.5]
                                           Mean Position [358]
4 SV Position
Latitude:
                39:11'36.62852" N
                                           39:11'36.67782" N
                123:11'00.34360" W
                                           123:11'00.44659" W
Longitude:
                                                    247.9
Height [m]:
                         251.8
                     k - station information
3 SV Position
               Best PDOP Position [ 2.5] Mean Position [157]
                39:11'36.93995" N
                                            39:11'36.76322" N
Latitude:
                                           123"11'00.69634" W
                123:11'00.75300" W
Longitude:
 STATION (mark) 2 ---
                                        k - station information
input data file 1 : 20020592.dat-
antenna height (m) .120---
                                    1010.0
met values used:
                pressure(mb)
                                            h - meteorological data
                 temperature(deg C)
                                      20.0
                                      50.0
                 relative humidity(%)
                        lat (dms) N
elon (dms) E
                                      39 🗸
                                                  36.66495
 x (m)
        -2709224.271
                                            11
                                                  59.56810
 y (m)
                                      236
                                            48
        -4142739.345
                        wlon (dms) W
                                                    .43190
                                      123
                                            11
         4009144.592
  z (m)
                                       244.2339
                        ht (m)
                   7000.8355 sigma (m)
slope distance (m)
                                             .015
normal section azimuth (dms) 14 43 51.65
                           0 35 6.58
vertical angle (dms)
                                                 71.498)m - solution file
        north(m) up(m) 1780.090
                                       6770.367
 east(m)
Delta lat(dms) 0 3 39.52775
Delta lon(dms) 0 1 14.17622
               75.3491
Delta ht(m)
Vector covariance matrix (m**2) :
                     dx.
   dx .785657836034D-04
   dy .673839449077D-04
                          .723510872927D-03
    dz -.843065752912D-04 -.504546156900D-03 .464958813305D-03
correlations:
          dx
                dy dz trop bias1 bias2 bias3 bias4 bias5 bias6
bias7
   dx 1.000
   dy .283 1.000
   dz -.680 -.870 1.000
       .000 .000
                  .000 1.000
  trop
       .000 .000
                  .000
                        .000 1.000
 biasl
                        .000 .000 1.000
 bias2
       .000 .000
                  .000
       .000 .000
                  .000
                        .000
                             .000 .000 1.000
 bias3
 bias4
       .000 .000 .000
                        .000
                             .000 .000 .000 1.000
       .000 .000 .000
                             .000 .000 .000 .000 1.000
 bias5
                        .000
       .000 .000 .000
                        .000
                             .000 .000 .000 .000 .000 1.000
 bias6
       .000 .000 .000
                             .000 .000 .000 .000 .000
                        .000
 bias7
1.000
```

Figure D-8. (Sheet 11 of 13)

```
Sensitivity to 10 meter error in station 1 coordinates
                    Solution
                                   Sigma
                                    .009
                    3799.006
     dx (m)
                                               9.999
                                                           .000
                                                                     -.002
     dy (m)
                    2554.013
                                    .027
                                               -.001
                                                         10.000
                                                                     -.001
                        .000
                                    .000
     dz
        (m)
                                                .000
                                                           .000
                                                                   10.000
  trop (%)
                                                           .000
                         .000
                                    .000
                                                .000
                                                                      .000
        (cycle)
                        .000
bias Ì
                                    .000
                                                .000
                                                            .000
                                                                      .000
bias 2
        (cycle)
                        .000
                                    .000
                                                .000
                                                            .000
                                                                      .000
        (cycle)
                                    .000
bias 3
                                                .000
                        .000
                                                            .000
                                                                      .000
                        .000
bias 4
        (cycle)
                                    .000
                                                .000
                                                            .000
                                                                      .000
        (cycle)
                                                           .000
bias 5
                        .000
                                    .000
                                                .000
                                                                      .000
bias 6 (cycle)
                        .000
                                    .000
                                                .000
                                                            .000
                                                                      .000
bias 7 (cycle)
                         .000
                                    .000
                                                .000
                                                            .000
                                                                      .000
 Results of integer bias search: .0549
                                       1.06578
                                                                 1.36295
                    0
                                              1
                    0
                                              0
                                                                        0
                    0
                                              0
                                                                        0
                    0
                                              0
                                                                        0
                    0
                                              0
                                                                        0
Ratio sum-of-squares(2) to sum-of-squares(1)
                                                           18.87
 Interval between epochs (sec) 120
                       4
 Epoch increment
 Number of measurements used in solution
Number of measurements rejected
                                                  161
                                                   56
                       .020 -
 RMS (cycles)
                                                          - RMS
 Elevation mask (deg)
                            15.0
 Edit multiplier
                              3.5
 Modified Hopfield troposhpere model used
Best tracking C/A code positions
Station 1
                                                       m - solution file
Pdop
              3.1
             -2713023.862
  x (m)
                              lat (dms)
                                           N
                                                39 7
                                                       57.13720
             -4145294.253
  Ā (w)
                              elon (dms)
                                              236 47 45.39187
123 12 14.60813
                                           E
  z (m)
              4003848.645
                              wlon (dms)
                                           W
                                                       14.60813
                             ht (m)
                                                170.2629
                         .432668ÒBĎ-03
clock offset(s)
freq offset(s/s)
                        -.11042348D-08
                        Carrier calibration(m)
 Code calibration(m)
     2
                  .2520
                                             0012
1 -
      3
                  .0552
                                            -.0006
1
      4
                 -.0249
                                            -.0007
1 -
                  .9292
                                            -.0008
  _
1
      6
                 -.2124
                                            -.0010
                 -.0181
                                             .0005
     8
                 -.1875
                                            -.0009
     9
                 -.1875
                                            -.0012
ī - 10
                 1.0630
                                            -.0014
Station 2
                                                       m - solution file
Pdop
            2.5
           -2709227.033
 x (m)
                                      (dma)
                               lat
                                            N
                                                   39
                                                       11
                                                             37.11338
 y (m)
z (m)
           -4142726.880
                               elon
                                      (dms)
                                                  236
                                            E
                                                       48
                                                             59.18749
            4009155.162
                                      (dms)
                               wlon
                                             W
                                                  123
                                                       11
                                                                .81251
                              ht (m)
                                                   244.0000
                         .88584966D-03
clock offset(s)
freq offset(s/s)
                         .58827784D-09
 Code calibration(m)
                         Carrier calibration(m)
     2
                 .2021
                                             .0007
1 -
1 -
     3
                 -.3682
                                            -.0011
1 -
      4
                 -.4199
                                            -.0010
                 -.5342
     5
                                            -.0013
1
     б
                 -.5234
                                            -.0011
                 -.2754
                                            -.0002
1 -
     8
                 -.6040
                                            -.0014
     9
                 -.8003
                                            -.0020
    10
                 -.6953
                                            -.0017
```

Figure D-8. (Sheet 12 of 13)

```
TRIMVEC GPS RELATIVE POSITIONING SOLUTION SUMMARY: VERSION 88.028
SOLUTION OUTPUT FILE: a:14022059.fix
STATION 1: Station ID: 2014 Session No.: 059-2 Feb 29,1988
07:24
Data-logging start time = 07:26 Data-logging stop time = 09:33
STATION 2: Station ID: 2002 Session #: 059-2 Feb 29,1988 07:21
Data-logging start time = 07:23 Data-logging stop time = 09:32
STATION COORDINATES:
Sta Ant (m) Latitude Longitude Hgt (m) 1 378 39:07'57.13720" N 123:12'14.60813" W 168.885
 2 [TRP] 0.120 39:11'36.66538" N 123:11'00.43314" W 244.226
2 [FLT] 0.120 39:11'36.66472" N 123:11'00.43068" W 244.249
 2 [FIX] 0.120 39:11'36.66495" N 123:11'00.43190" W 244.234
Origin of station 1 coordinates : Best C/A code tracking solution
 SOLUTION SUMMARY:

    dx (m)
    dy (m)
    dz (m)
    dh (m)

    3798.989
    2554.042
    5296.822
    75.341

    3799.022
    2553.984
    5296.821
    75.365

    3799.006
    2554.013
    5296.817
    75.349

    0.016
    -0.029
    0.004
    0.016

                                                                                            RDOP
Solution
                 3798.90.
3799.022
TRIPLE
FLOAT
FIXED
FLT-FIX
                                                                                             n/a
                                                                                             n/a
                                                                                              n/a
                0.016

      Solution Slope (m)
      sig Epochs/Rejected
      Epoch int
      Epoch inc

      TRIPLE 7000.8406 [0.032]
      168/ 1
      150 (secs)
      5 (epochs)

      FLOAT 7000.8363 [0.036]
      167/ 50
      120 (secs)
      4 (epochs)

      FIXED 7000.8355 [0.015]
      161/ 56
      120 (secs)
      4 (epochs)

Fixed solution quality factor: 18.9
                                    0.020 (cycles)
Fixed solution rms:
Maximum float - fixed delta: 2.0 (cm)
Integers found, RMS is OK, FIXED solution recommended.
```

Figure D-8. (Sheet 13 of 13)

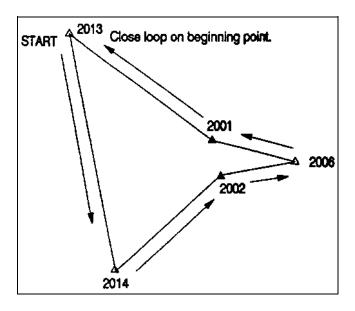


Figure D-9. Loop closure (Ukiah)

- a. The input data file for a GEOLAB adjustment is called an "IOB" file. An IOB file can be created using a text editor program or with a GEOLAB option called "GPS Environment." An IOB file is specific to the GEOLAB adjustment software and may or may not be required by other least-square adjustment software (refer to Chapter 11 or the owner's manual). The GEOLAB Environment option takes GPS baseline solution files developed by most GPS manufacturers and automatically sets up an IOB file for adjustment.
- *b*. The IOB input file generally consists of the following information:

- (1) *Top line*. Title Record usually a project name and an adjustment number.
- (2) Second line. Options Record this record specifies which GEOLAB options are to be activated for processing.
- (3) *Third line*. Ellipsoid Specification Record Prints ellipsoid parameters chosen in the Options Record or as chosen by the user.
- (4) Station information section. All stations must have their coordinates defined here. The coordinates must be given as ellipsoidal latitude, longitude, and orthometric height, or as Cartesian coordinates. In this section, stations are either held fixed or are to be adjusted. If stations are not held fixed, estimated coordinates are input.
- (5) Auxiliary parameter definition record. The auxiliary parameter group definition record is optional, but can be used if GEOLAB is to solve for various scale, orientation, translation, or constant parameters. In the sample GEOLAB input, enough vertical and horizontal control is held fixed to solve for SCALE and ROTATION. Rotation is about the Cartesian X-axis, Y-axis, and Z-axis.
- (6) Observation records section. In the example GEOLAB input file, only GPS observations are entered. Each baseline is entered separately with the station name and Cartesian coordinate differences between the stations, which is the computed baseline. These can also be entered as $\Delta x=0$, $\Delta y=0$, $\Delta z=0$, for station 1 and the 3D

Baseline	△ x , m	△ y, m	△ z , m	Distance, m
13142059.FIX 2013 -> 2014	-3,367.429	-7,891.019	-10,410.673	13,490.362
14021059.FIX 2014 -> 2002	3,799.005	2,554.018	5,296.798	7,000.823
02053056.FIX 2002 -> 2006	953.294	-748.319	-16.709	1,212.035
06013056.FIX 2006 -> 2001	-666.617	1,441.548	908.280	1,829.593
01132059.FIX 2001 -> 2013	-718.244	4,643.775	4,222.288	6,317.297

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baseline for station 2. For example, baseline 1 would be entered as:

STA	ATION	ΔX	Δ	$\Delta \mathbf{Z}$
92	2001	0.000	0.000	0.000
92	2006	-666.617	1,441.548	908.280

The correlation matrix elements from the baseline solution are also entered and the last line of the observation record is the standard deviation for Δx , Δy , and Δz .

- c. The following figure (Figure D-10) taken from a GEOLAB input is annotated with the convention above.
- d. Once an IOB file containing parameters necessary to perform an adjustment has been completed, the adjustment can begin. The first step is to select the baselines needed for the adjustment. The baselines chosen must have been processed adequately, as detailed in Chapter 10, or as recommended by the GPS manufacturer.
- e. The example IOB file shown in Figure D-10 was adjusted as shown in Figure D-11. Figure D-11 has been annotated for a general discussion of the results.
- f. For the first adjustment (Figure D-11), one point was held fixed in 3D, producing a free adjustment (refer to Chapter 10 for further detail). A free adjustment checks the internal consistency of a GPS survey.
- g. A second adjustment (not shown) can be made to check the existing network if these control points are directly tied together with GPS baselines. To do this with GEOLAB, the user must set up an IOB file with only the fixed control and the respective baselines connecting them. Hold fixed all control except one point, then adjust. Next, fix that control point and free one of the others, and keep repeating this procedure until all control points have been allowed to be checked against their true position. If the position of one control point is "bad," that point can generally be omitted from the subsequent constrained adjustment or allowed to adjust with the other points.
- *h.* A final constrained adjustment (Figure D-12) should hold fixed all good horizontal and vertical control. Adjust and check the output as detailed in Chapter 11.

D-6. Check of the Final Adjustment

After each adjustment was run, the 2D and 1D station (absolute) error ellipse for each adjusted point was reviewed (for further discussion on error ellipses and

adjustments, refer to Chapter 11). These are listed as major semi-axis, minor semi-axis, major azimuth, and vertical (as shown on page 15 of the free adjustment and page 16 of the constrained adjustment). The size of the error ellipses listed in this portion of the GEOLAB adjustment are an indication of the internal consistency of the GPS survey. The smaller the size of the ellipse, the better the survey. The size of the ellipse will also generally become larger as the project size increases. In the constrained adjustment shown, the major semi-axis and minor semi-axis are of the millimeter level (0.0066 and 0.0048 mm for 2001 and 0.0062 and 0.0044 mm for 2002, respectively) - which is acceptable.

- a. The 2D and 1D relative error ellipses and line accuracies (i.e., precision) between survey points were checked. These are listed as major semi-axis, minor semi-axis, major azimuth, and vertical, spatial distance, and precision (as shown on page 16 of the free adjustment and page 17 of the constrained adjustment). When checking these values, one should remember they are relative values. The relativity of points used in the adjustment can sometimes produce deceptive values, higher major semi-axis and minor semi-axis values: this may occur between points that are close together, but have not been tied together by a baseline. Because of the possibility of the production of deceptive results, the user must take special care when reviewing these values. In the constrained adjustment shown, the major semi-axis and minor semi-axis are of the millimeter level (0.0045 and 0.0036 for the baseline 2001->2002). The project precision in parts per million (PPM) is also listed in this portion of the adjustment and should be checked.
- b. The histograms in the GEOLAB adjustments were reviewed. The histogram is a visual representation of the standardized (normalized) residuals. The histogram shows whether the residuals are symmetrical about the mean residual, the total spread of values of the residuals, the frequencies of the different values, and how peaked or how flat the distribution of the residuals may be. A generally good looking histogram has data that, when graphed, is in the shape of a bell curve.
- c. The free adjustment line accuracy precessions shown on page 16 of Figure D-11 are the primary criteria used to evaluate the survey adequacy. The worst precision (4.182 ppm between 2001 and 2013) equates to 1:239,000. This far exceeds the required project accuracy

¹ Note the page numbers listed on the right side of the sheets of Figures D-11 and D-12. Each sheet contains several pages of the GEOLAB adjustments.

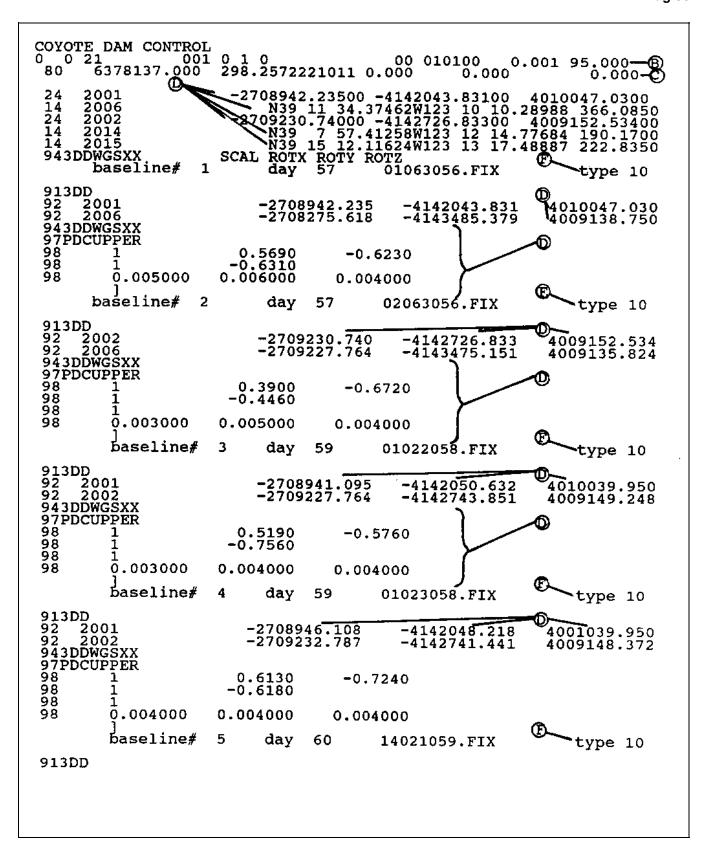


Figure D-10. GEOLAB input (Ukiah) (Continued)

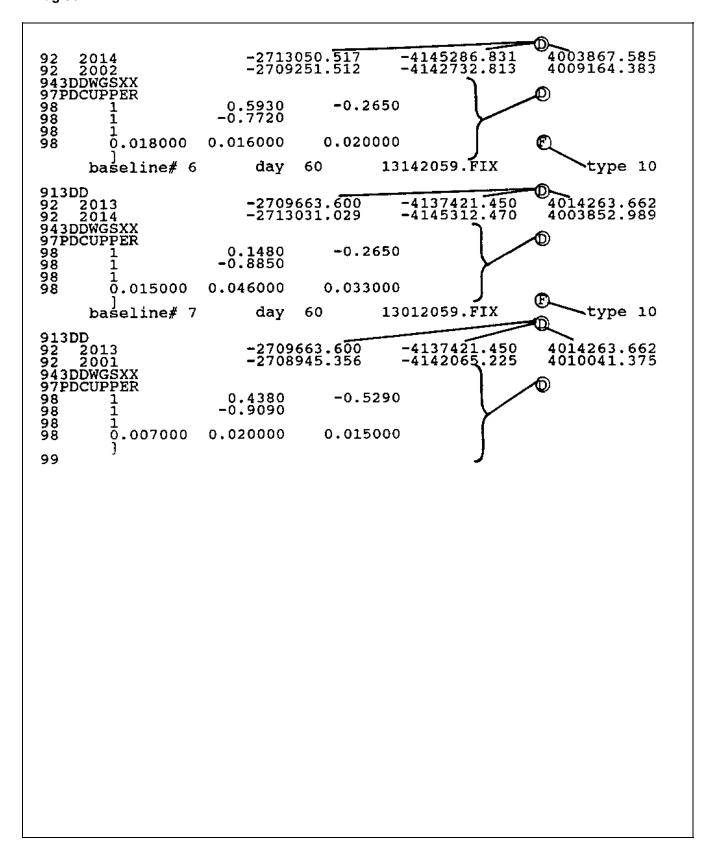


Figure D-10. (Concluded)

<u>U.</u>	S. ARMY ENGINEER TO COYOTE DAM FREE AD	POGRAPHIC LABORATORIE JUSTMENT NAD-83	<u>s</u>	
A= 6378137.000 B=	6356752.314 x0=	0.000 YO=	0.000 ZO= 0.	000
PREPARE: ASC PREPARE successfully	II input file: <coyo< td=""><td>ote_2.iob>.</td><td></td><td>•</td></coyo<>	ote_2.iob>.		•
GeoLab - V1.82S, (C)	1985/86/87 BitWise	Ideas Inc. (10320769	6] Page	0
GETUP:		••••••		-
PARAME	TERS	OBSERVA	TIONS	[]
Description	Number	Description	Number	 - -
All Stations Fixed Stations Free 3-D Stations Free 2-D Stations Free 1-D Stations Coord. Parameters Astro. Latitudes Astro. Longitudes Geoid Records All Aux. Pars. Direction Pars. Scale Parameters Constant Pars. Translation Pars. Total Parameters	1 4 0 0 12 0 0 0 0 0	Directions Distances Azimuths Vertical Angles Zenithal Angles Angles Heights Height Differences Auxiliary Params. 2-0 Coords. 2-0 Coords. 3-D Coords. 3-D Coord. Diffs. Total Observations	0 0 0 0 21	
***************************************		Ideas Inc. [103207696	6} Page	- 1
		SELECTED OPTIONS	,	· -
OPTION		SELECTION		-
Confidence Reg Print Input St Variance Facto Confidence Lev Dual-Height Mo Print Solution Printed Ellips Print Adjusted Print Histogra Print Residual Variance Facto Residual Rejec	ions ions Selected ion Dimensions ation Data r Knowledge el for Statistics de Vector oidal Coordinates X, Y, Z ms res s r Usage tion Criterion sure Limit Factor	Adjustment Metre 2 All 1-D, 2-D, and 3 On Known 95.000 Off On All Iteration 5 Decimal Place On On On All Iteration I	ons es ons	
GeoLab - V1.82S, (C)	1985/86/87 BitWise	Ideas Inc. [103207696	6) Page (- 2

Figure D-11. GEOLAB adjustment output (free) (Sheet 1 of 7)

						zo= 0.00	
	DESCRIPTOR						-
			•••				
006							_
	ELLIPSOIDAL :	39 11	34.37462	-123 10	10.28988	336.0850	
	ASTRONOMIC :	39 11	34.37462	-125 10	10.28988	336.0850	,
	GEDIDAL :	-2706	99777 0854	-414	3/0/ 7721	4000147 RO37	
	CARTESIAN :	-2100	3200.4700	* 4 14	3474.7721	40071471075	•
001							
	ELLIPSOIDAL :	39 12	14.43422	-123 11	6.45941	243.8658	3
	ASTRONOMIC :	39 12	14.43422	-123 11	6.45941	243.8658	3
	GEOIDAL :	0 0	0.00000	0 0	0.00000	0.0000)
	CARTESIAN :	-2708	3942.2350	-414	2043.8310	4010047.0300)
000							
UU2	CITTOCOTOAL -	30 11	37 NO454	-127 55	0.06286	2/.T RQ15	
	ACTROURAL :	37 II 30 11	37 00656	-123 11	0.94286	243.001. 243.881	í
	GEOIDAL -	0 0	0.00000	0 0	0.00000	0.0000	,
	CARTESIAN :	-2709	230.7400	-414	2726.8330	4009152.5340	5
014							_
	ELLIPSOIDAL :	39 7	57.44196	-123 12	15.70589	188.7219	?
	ASTRONOMIC :	39 7	57.44196	-123 12	15.70589	188.7219	?
	GEOIDAL :	0 0	0.00000	0 0	0.00000	U.UUU(,
	CARTESIAN :	-2713	0050.5170	-414	2200.8310	4003887.3830	,
013							
0.13	ELLIPSOIDAL :	39 15	11.55819	-123 13	17.15396	220.5009	•
	ASTRONOMIC :	39 15	11.55819	-123 13	17.15396	220.5009)
	GEOIDAL :	0 0	0.00000	0 0	0.00000	0.0000)
	CARTESIAN :	-2709	663.6000	-413	7421.4500	4014263.6620)
successfi	ully completed						
		(07 Diel)			073074041	Dage	3
- V1.82	s, (L) 1985/86	OF BITWI	se toeas	inc. [i	032070903	rage	
: NOTE 6	: Reo	rdering s	as done.				
TO	OBS TYPE		QBSER\				
2006	3-D X-Coor	Diff	666	.6170	0.0037	-4.8608	
2006	3-D Y-Coor	J Diff	- 1441	.5480	0.0045	-9.3931	
2006	3-D Z-Coor	J D1ff	-908	5,2800 1 2050	0.0028	9.1455 -7.0770	
2006	3-D Y-0000	3 DITT 4 Diff	.7/.0	1.293U	0 0044 ሰ10055	866U, C- 1153 OI.	
2006 2006	3-D 7-Coop	a pitt 4 Niff	-140		0.0044	17,0211 70A0 Ct	
2000	3.0 2 6001			77 (100	0.002	12.0073	
2002							
2002			-693	3.2230	0.0030	10.2210	
2002			-891	.5780			
2002							
2002							
			,			2,000	
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[103207696] ENOTE 6: Reordering was done. 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Figure D-11. (Sheet 2 of 7)

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24 2002 LATITUDE 39 11 36.93927 0.00000 39 11 36.9392 24 2002 LONGITUDE -123 11 0.60115 -0.00000 -123 11 0.6011 24 2002 HEIGHT 265.51530 0.00001 265.5153
24 2002 LONGITUDE -123 11 0.60115 -0.00000 -123 11 0.6011 24 2002 HEIGHT 265.51530 0.00001 265.5153
24 2002 HEIGHT 265.51530 0.00001 265.5153
24 2014 LATITUDE 39 7 57.41258 -0.00000 39 7 57.4125
24 2014 LATITUDE 39 7 57.41258 -0.00000 39 7 57.4125 24 2014 LONGITUDE -123 12 14.77684 -0.00000 -123 12 14.7768 24 2014 HEIGHT 190.16712 0.00004 190.16712
24 2014 HEIGHT 190.16712 0.00004 190.1671
24 2013 LATITUDE 39 15 12.11624 -0.00000 39 15 12.1162
24 2013 LONGITUDE -123 13 17.48887 -0.00000 -123 13 17.4888
24 2013 HEIGHT 222.83570 0.00003 222.8357
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, and the second
Adjusted Cartesian Coordinates:
CODE IDENT. X-COORDINATE Y-COORDINATE Z-COORDINATE
24 2001 -2708947.0978 -4142053,2284 4010056,1788
24 2002 -2709233.7714 -4142746.4510 4009164.5970
24 2014 -2713032.7730 -4145300.4675 4003867.7943
24 2013 -2709665.3421 -4137409.4529 4014278.4662

Figure D-11. (Sheet 3 of 7)

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RESID: STATION	3-D COORD DIFFS	STD.DEV.	RESIDUAL	STD.DEV.	STAN.RES.	
2001	-2708942.2350 -4142043.8310					
2006	4010047.0300 -2708275.6180 -4143485.3790 4009138.7500	0.0050 0.0060 0.0040	0.0020 0.0043	0.0040 0.0044 0.0026	0.4913 0.9722 -2.1131	
********	4009130.7300 ***************	End of Obser	vation Set	0.0020 E2E3EEEE####	FEESET:	.
2002	-2709230.7400 -4142726.8330 4009152.5340					
2006	-2708277.4450 -4143475.1510	0.0030 0.0050	-0.0024 -0.0031	0.0015 0.0031	-1.5684 -1.0050	
	4000135 8240	0.0040	0.0063	0.0026	2,4021	
2001	-2708941.0950 -4142050.6320	End of Obser	vation Set		=1555====#£	
2002	4010040.8370 -2709227.7640 -4142743.8510	0.0030 0.0040	-0.0046 -0.0036	0.0020 0.0031	-2.2695 -1.1723	
	4000140.7480	0.0040	0.0072	0.0032	2.2790	
	-2708946.1080	End of Obser	rvation set	8525	BH	
2001	-4142048.2180 4010039.9500					
2002	-2709232.7870 -4142741.4410	0.0040 0.0040 0.0040				
	4009148.3720			0.0032	-1.1996	
2014	-2713050.5170 -4145286.8310	End of Obse	rvation set			
2002	4003867.5850 -2709251.5120 -4142732.8130	0.0180 0.0160 0.0200	-0.0034 -0.0015	0.0132 0.0077	-0.1983	
	4009164.3830	0.0200 End of Observ	U.UU4/	0.0129	0.3661 	
2013	-2709663.6000 -4137421.4500 4014263.6620					
2014	-2713031.0290 -4145312.4700 4003852.9890	0.0150 0.0460 0.0330	-0.0019 0.0054 0.0011	0.0092 0.0407 0.0275	0.1332	!
GeoLab -	V1.82S, (C) 1985/8	36/87 BitWise	ideas Inc.	[103207696]	Page	10
RESID:					·	
STATION	3-D COORD DIFFS		RESIDUAL		STAN.RES.	
	=======================================	End of Obse	rvation Set		.==========	====
2013	-2709663.6000 -4137421.4500 4014263.6620			<u>-</u>	.	
2001	-2708945.3560 -4142065.2250 4010041.3750	0.0070 0.0200 0.0150		0.0076	-0.0670)
	4010041.3750	U.U.JU - End of Obco	cvetion Set			

Figure D-11. (Sheet 4 of 7)

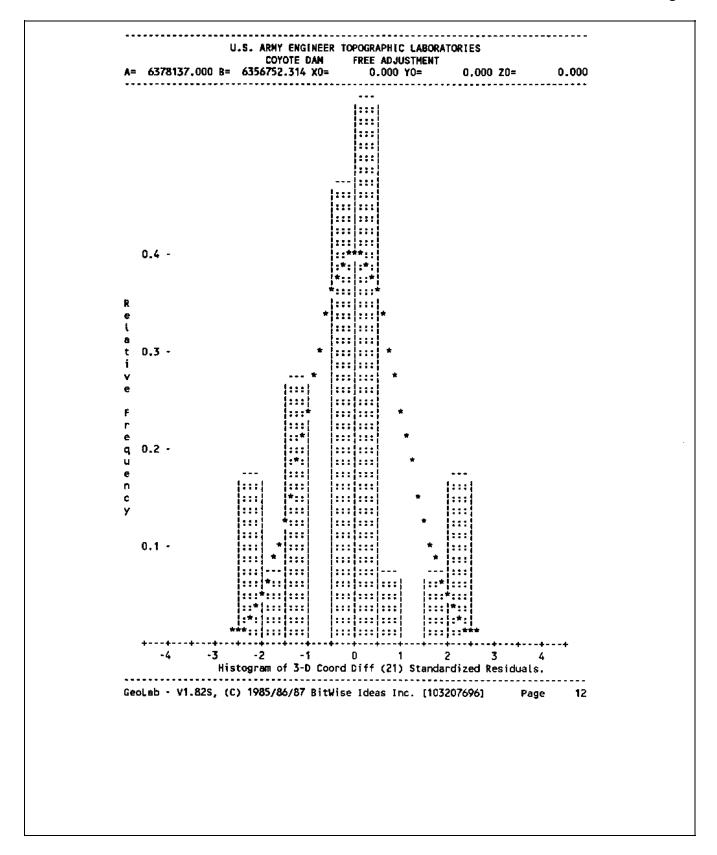


Figure D-11. (Sheet 5 of 7)

= 65/815/.UUU B=	4754757 71/ VA-	FREE ADJUSTMENT	0.000 70=	0.000
		0.000 YO=		
		S SUMMAR		
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Residual Cri			2,5985	!
Convergence		0.	.001000	j
	ion Counter Value	1 .	5.0000	į
Confidence L		,	0.0000	!
	lagged Residuals oriance Factor	1	1.3376	
Number of De	grees of Freedom		9	
	Chi-Square Test o	n the Variance Facto	or:	1
		.0000 < 4.4579e+0		
			-	
		ST PASSES.		
RESID successfully	y completed.			
Caal sh - V1 829		ise Ideas Inc. [103		e 13
		••••••		
ELLIPSE:				
	factor used =	computed using the		
; ! Estimat e	d variance factor =	1.33757		
į	nsion factor =			
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1-D expa 2-D expa	nsion factor =	1,960		
1-D expa 2-D expa 3-D expa Note tha	nsion factor = nsion factor = nsion factor =	1,960 2.448 2.795 affidence regions, pr	ecisions are and the spatial	
1-D expa 2-D expa 3-D expa Note tha computed distance Error el were not	nsion factor = nsion factor = t, for relative cor from the ratio of between the two st lipses for which al	1,960 2.448 2.795 offidence regions, prothe major semi-axistations. Il covariance matrix I, are marked with a	and the spatial elements	
1-D expa 2-D expa 3-D expa Note tha computed distance Error el were not	nsion factor = nsion factor = t, for relative cor from the ratio of between the two st lipses for which al	1,960 2.448 2.795 Infidence regions, prothe major semi-axistations. Il covariance matrix are marked with a	elements n asterisk (*).	•••••
1-D expa 2-D expa 3-D expa Note tha computed distance Error el were not	nsion factor = nsion factor = t, for relative cor from the ratio of between the two st lipses for which al	1,960 2.448 2.795 offidence regions, prothe major semi-axistations. Il covariance matrix I, are marked with a	elements n asterisk (*).	•••••
1-D expa 2-D expa 3-D expa Note tha computed distance Error el were not	nsion factor = nsion factor = nsion factor = t, for relative cor from the ratio of between the two st lipses for which al computed by INVERT	1,960 2.448 2.795 Infidence regions, prothe major semi-axistations. Il covariance matrix are marked with a	elements in asterisk (*).	•••••
1-D expa 2-D expa 3-D expa Note tha computed distance Error el were not GeoLab - V1.82S, ELLIPSE:	nsion factor = nsion factor = nsion factor = t, for relative cor from the ratio of between the two st lipses for which al computed by INVERT	1,960 2.448 2.795 Infidence regions, prothermajor semi-axistations. Il covariance matrix I, are marked with a semi-axistations. Il covariance matrix I, are marked with a semi-axistations.	elements in asterisk (*).	•••••
1-D expa 2-D expa 3-D expa Note tha computed distance Error el were not GeoLab - V1.82S, ELLIPSE:	nsion factor = nsion factor = nsion factor = t, for relative corfrom the ratio of between the two st lipses for which all computed by INVERT	1,960 2.448 2.795 ofidence regions, prothermajor semi-axistations. Il covariance matrix, are marked with a size Ideas Inc. [103] I COMFIDENCE REGIONS EMI-AXIS AZ(MAJ) 0.0054 124.77	elements in asterisk (*). 207696] Pag (95.000 %): VERTICAL	•••••
1-D expa 2-D expa 3-D expa Note tha computed distance Error el were not GeoLab - V1.82S, ELLIPSE: IDENT. MAJOR	nsion factor = nsion factor = nsion factor = t, for relative cor from the ratio of between the two st lipses for which al computed by INVERTOR (C) 1985/86/87 Bits 2-D AND 1-D STATION SEMI-AXIS MINOR SI 0.0073 0.0074	1,960 2.448 2.795 If idence regions, prothermajor semi-axistations. It covariance matrix, are marked with a size Ideas Inc. [103] I COMFIDENCE REGIONS EMI-AXIS AZ(MAJ) 0.0054 124.77 0.0047 130.94	elements in asterisk (*). 207696] Pag (95.000 %): VERTICAL 0.0112 0.0106	•••••
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1-D expa 2-D expa 3-D expa Note that computed distance Error element note Geolab - V1.82S, ELLIPSE: IDENT. MAJOR 2001 2002	nsion factor = nsion factor = nsion factor = t, for relative cor from the ratio of between the two st lipses for which al computed by INVERT (C) 1985/86/87 Bitt 2-D AND 1-D STATION SEMI-AXIS MINOR SI 0.0073 0.0074 0.0277	1,960 2.448 2.795 If idence regions, prothermajor semi-axistations. It covariance matrix, are marked with a size Ideas Inc. [103] I COMFIDENCE REGIONS EMI-AXIS AZ(MAJ) 0.0054 124.77 0.0047 130.94	elements in asterisk (*). 207696] Pag (95.000 %): VERTICAL 0.0112 0.0106	•••••

Figure D-11. (Sheet 6 of 7)

A= 637	8137.000	COY B= 6356752	OTE DAM .314 XO=	FREE O	ADJUSTA :OY 000.	RECRATORIES (ENT 0.000 ZO=	0.00
ELLIPSE	:	2-D AND 1-I	RELATIV	VE STATIO	N CONFI	DENCE REGIONS (9	95.000 %):
FROM	то	MAJ.SEMI	MIN.SEMI	AZ(MAJ)	VERTICA	L SPATIAL DIST.	PRECISIO
2001	2002	7400	REOD O	105 27	n nns	1145 1954	7 891 DD
2001	2014	0.0272	0.0204	84.07	0.047	S 8005 2704	3.00, 77
2001	2013	0.0264	0.0125	94.67	0.049	4 6317,2966	4.182 PR
2002	2014	0.0271	0.0203	83.67	0.047	3 7000.8237	3.871 PP
2002	2013	0.0267	0.0130	94.73	0.049	9 7404.1516	3.612 PP
2014	2013	0.0359	0.0216	91.44	0.060	1165.1856 1165.1856 1165.1856 117.2966	2.665 PP
					,		
				IUC	as the.	[103207696]	Page 1
ELLIPSE	:	3-D STATIO	CONFIDE	ENCE REGI	ONS (9	5.000 %):	
		MAJOR SEMI	-AXIS	MEDI	M SENI-	AXIS MINO	R SEMI-AXIS
2001		0	.0161			0082 4.7 A= 2 0082 8.4 A= 3 0316 0.7 A=17	ก กกรด
2001		4=180 0 V=	80 4	4=20	DROV=	47 4= 2	0.00.0 7 A V A D
2002		0	-0152	W. E.	ν <u>-</u>	0082	0.054
		A=161.8 V=	79.9	A=30)7.9 V≓	8.4 4= 3	8.7 V= 5 6
2014		0	.0690		a.	0316	0_0237
		A=345.0 V=	86.1	A= 8	35.7 V=	0.7 A=17	5.8 V= 3.8
2013							
		A= 94.5 V=	72.1	A=27	79.0 V=	17.9 A=18	
GeoLab	- V1.82S.	(C) 1985/8	6/87 Bit	Vise Idea	s Inc.	[103207696]	Page 1
	•••••			•••••			•••••
ELLIPSE	: 	3-D RELATIV	Æ STATIC	ON CONFID	ENCE RE	GIONS (95.000 %)):
FROM	TO	MAJOR-SEM	1 MED	SEMI MINO	R-SEMI	SPATIAL DIST.	PRECISIO
	2002	0.011	7 0.0	0051	0.0044	1165,1856	10.011 PP
2001	2002						
2001	2002	A= 0 V=9	D A= 90 '	V= 0 A=	0 V= 0		
2001	2014	A= 0 V=9	D A= 90 1	V= 0 A= 0311	0 V= 0 0.0228	8095.2706	8.392 PP
2001	2014	A= 0 V=90 0.0679 A=347 V=80	D A= 90 1 9	V= 0 A= 0311 V= 1 A=17	0 V= 0 0.0228 4 V= 4	8095.2706	
2001	2014	0.073	9 0.	V= 1 A=11 0201	0.0142	8095.2706 6317.2966	
2001 2001 2001	2013	0.0739 A= 93 V=7	9 0.1 2 A=279	v= 1 A=11 0201 v=18 A=18	0.0142 38 V= 2	6317.2966	11.704 PP
2001	2014 2013 2014	0.0734 0.0734 A= 93 V=73 0.067	9 0.0 2 A=279 1 7 0.0	V= 1 A=11 0201 V=18 A=18 0309	0.0142 38 V= 2 0.0226	8095.2706 6317.2966 7000.8237	
2001 2001 2001 2002	2013 2014	0.073 A= 93 V=7: 0.067 A=342 V=8	9 0.1 2 A=279 1 7 0.1 5 A= 83 1	V= 1 A=17 0201 V=18 A=18 0309 V= 1 A=17	0.0142 38 V= 2 0.0226 3 V= 4	6317.2966 7000.8237	11.704 PP 9.666 PP
2001 2001 2001	2013	0.073 A= 93 V=7 0.067 A=342 V=8 0.074	9 0.1 2 A=279 1 7 0.1 5 A= 83 1	v= 1 A=17 0201 V=18 A=18 0309 V= 1 A=17 0210	0.0142 38 V= 2 0.0226 73 V= 4 0.0148	6317.2966	11.704 PP
2001 2001 2001 2001 2002 2002	2013 2014 2013	0.073' A= 93 V=7' 0.067' A=342 V=8' 0.074' A= 93 V=7'	9 0.1 2 A=279 1 7 0.1 5 A= 83 1 5 0.1 2 A=278 1	V= 1 A=10 0201 V=18 A=18 0309 V= 1 A=17 0210 V=18 A=18	0.0142 38 V= 2 0.0226 73 V= 4 0.0148 38 V= 1	6317.2966 7000.8237 7404.1516	11.704 PP 9.666 PP 10.064 PP
2001 2001 2001 2002	2013 2014	0.073' A= 93 V=7' 0.067' A=342 V=8' 0.074' A= 93 V=7' 0.088'	9 0.1 2 A=279 1 7 0.1 5 A= 83 1 5 0.1 2 A=278 1	V= 1 A=10 0201 V=18 A=18 0309 V= 1 A=17 0210 V=18 A=18 0363	0.0142 38 V= 2 0.0226 73 V= 4 0.0148 38 V= 1 0.0245	6317.2966 7000.8237	11.704 PP 9.666 PP 10.064 PP
2001 2001 2001 2002 2002 2014	2013 2014 2013 2013	0.073' A= 93 V=7' 0.067' A=342 V=8' 0.074' A= 93 V=7'	9 0.0 2 A=279 1 7 0.1 5 A= 83 1 5 0.1 2 A=278 1 7 0.1	V= 1 A=10 0201 V=18 A=18 0309 V= 1 A=17 0210 V=18 A=18 0363	0.0142 38 V= 2 0.0226 73 V= 4 0.0148 38 V= 1 0.0245	6317.2966 7000.8237 7404.1516	11.704 PP 9.666 PP 10.064 PP

Figure D-11. (Sheet 7 of 7)

			POGRAPHIC LABORATORIES IED ADJUSTMENT KAD-83		
A=	6378137.000 B=	6356752.314 XO=	0.000 YO= 0.00	10 ZO=	0.000
PREI	PARE: ASCII PARE successfully	input file: <coyote_ y completed.</coyote_ 	1.iob>.		
Geol	ab - V1.82S. (C)	1985/86/87 BitWise	[deas Inc. [103207696]	Page	0
	••••••		***************************************		
GETU	JP:				
	••••••••	TERS	OBSERVATI	ONS	
 	Description	Number	Description	Number	
Al	l Stations	5	Directions	0	
	xed Stations	3	Distances	ŏ	
Fr	ee 3-D Stations	2	Distances Azimuths Vertical Angles	ō	
Fr	ee 2-D Stations	Ō	Vertical Angles	ŏ	
Fr	ee 1-D Stations			Ŏ	į
	ord. Parameters	6	Angles	Ö	
	tro. Latitudes	Ò	Heights	Ō	Ì
As	tro. Longitudes	0	Height Differences	Ō	i
¦ Ge	oid Records	0	Auxiliary Params.	0	į
AL	l Aux. Pars.	4	Angles Heights Height Differences Auxiliary Params. 2-D Coords.	0	İ
¦ Di	rection Pars.	Ų	¿ 2-U COOPO. DITTE. ;	0	į
	ale Parameters :		3-D Coords.	0	
	nstant Pars.	. 0	3-D Coord. Diffs.	21	İ
•	tation Pers.	3	ļ		ŀ
Tr	anslation Pars.	0			1
•					i
_		•••••			
To	tal Parameters	10	Total Observations	21	
To	tal Parameters	10 Degrees of Freed		21	
GeoL	ab - V1.82S, (C)	Degrees of Freed 1985/86/87 BitWise	om = 11 Ideas Inc. [103207696]		1
	ab - V1.82S, (C)	Degrees of Freed 1985/86/87 BitWise	om = 11		1
GeoL	ab - V1.82S, (C)	Degrees of Freed 1985/86/87 BitWise	om = 11 Ideas Inc. [103207696]		1
GeoL	ab - V1.82S, (C)	Degrees of Freed 1985/86/87 BitWise SUMMARY OF	om = 11 Ideas Inc. [103207696] SELECTED OPTIONS SELECTION		1
GeoL	ab - V1.82S, (C) P: OPTION Computation No	Degrees of Freed 1985/86/87 BitWise SUMMARY OF	om = 11 Ideas Inc. [103207696] SELECTED OPTIONS		1
GeoL	ab - V1.82S, (C) P: OPTION Computation No Linear Unit Maximum Iterat	Degrees of Freed 1985/86/87 BitWise SUMMARY OF	om = 11 Ideas Inc. [103207696] SELECTED OPTIONS SELECTION Adjustment		1
GeoL	ab - V1.82S, (C) P: OPTION Computation Mo Linear Unit Maximum Iterat Confidence Reg Confidence Reg Print Input St	Degrees of Freed 1985/86/87 BitWise SUMMARY OF de ions ions Selected ion Dimensions ation Data	om = 11 Ideas Inc. [103207696] SELECTED OPTIONS SELECTION Adjustment Hetre 2 All 1-D, 2-D, and 3-D	Page	1
GeoL	ab - V1.82S, (C) P: OPTION Computation Mo Linear Unit Maximum Iterat Confidence Reg Confidence Reg Print Input St Variance Facto	Degrees of Freed 1985/86/87 BitWise SUMMARY OF de ions ions Selected ion Dimensions ation Data r Knowledge	om = 11 Ideas Inc. [103207696] SELECTED OPTIONS SELECTION Adjustment Metre 2 All 1-D, 2-D, and 3-0	Page	1
GeoL	ab - V1.82S, (C) P: OPTION Computation Mo Linear Unit Maximum Iterat Confidence Reg Confidence Reg Print Input St Variance Facto Confidence Lev	Degrees of Freed 1985/86/87 BitWise SUMMARY OF de ions ions Selected ion Dimensions ation Data r Knowledge el for Statistics	om = 11 Ideas Inc. [103207696] SELECTED OPTIONS SELECTION Adjustment Metre 2 All 1-D, 2-D, and 3-D On Known 95.000	Page	1
GeoL	P: OPTION Computation Mo Linear Unit Maximum Iterat Confidence Reg Confidence Reg Print Input St Variance Facto Confidence Lev Dual-Height Mo	Degrees of Freed 1985/86/87 BitWise SUMMARY OF de ions ions Selected ion Dimensions ation Data r Knowledge el for Statistics de	om = 11 Ideas Inc. [103207696] SELECTED OPTIONS SELECTION Adjustment Metre 2 All 1-D, 2-D, and 3-D On Known	Page	1
GeoL	P: OPTION Computation Mo Linear Unit Maximum Iterat Confidence Reg Confidence Reg Print Input St Variance Facto Confidence Lev Dual-Height Mo Print Solution	Degrees of Freed 1985/86/87 BitWise SUMMARY OF de ions ions Selected ion Dimensions ation Data r Knowledge el for Statistics de Vector	om = 11 Ideas Inc. [103207696] SELECTED OPTIONS SELECTION Adjustment Metre 2 All 1-D, 2-D, and 3-D On Known 95.000 Off On All Iterations	Page	1
GeoL	P: OPTION Computation Mo Linear Unit Maximum Iterat Confidence Reg Confidence Reg Print Input St Variance Facto Confidence Lev Dual-Height Mo Print Solution Printed Ellips	Degrees of Freed 1985/86/87 BitWise SUMMARY OF de ions ions Selected ion Dimensions ation Data r Knowledge el for Statistics de Vector oidal Coordinates	om = 11 Ideas Inc. [103207696] SELECTED OPTIONS SELECTION Adjustment Metre 2 All 1-D, 2-D, and 3-D On Known 95.000 Off On All Iterations 5 Decimal Places	Page	1
GeoL	P: OPTION Computation Mo Linear Unit Maximum Iterat Confidence Reg Print Input St Variance Facto Confidence Lev Dual-Height Mo Print Solution Printed Ellips Print Adjusted	Degrees of Freed 1985/86/87 BitWise SUMMARY OF de ions ions Selected ion Dimensions ation Data r Knowledge el for Statistics de Vector oidal Coordinates X, Y, Z	om = 11 Ideas Inc. [103207696] SELECTED OPTIONS SELECTION Adjustment Metre 2 All 1-D, 2-D, and 3-D On Known 95.000 Off On All Iterations 5 Decimal Places On	Page	1
GeoL	ab - V1.82S, (C) P: OPTION Computation Mo Linear Unit Maximum Iterat Confidence Reg Print Input St Variance Facto Confidence Lev Dual-Height Mo Print Solution Printed Ellips Print Adjusted Print Histogram	Degrees of Freed 1985/86/87 BitWise SUMMARY OF de ions ions Selected ion Dimensions ation Deta r Knowledge el for Statistics de Vector oidal Coordinates X, Y, Z	Ideas Inc. [103207696] SELECTED OPTIONS SELECTION Adjustment Metre 2 All 1-D, 2-D, and 3-D On Known 95.000 Off On All Iterations 5 Decimal Places On	Page	1
GeoL	ab - V1.82S, (C) P: OPTION Computation Mo Linear Unit Maximum Iterat Confidence Reg Print Input St Variance Facto Confidence Lev Dual-Height Mo Print Solution Printed Ellips Print Adjusted Print Histogram Print Misclosu	Degrees of Freed 1985/86/87 BitWise SUMMARY OF de ions ions Selected ion Dimensions ation Data r Knowledge el for Statistics de Vector oidal Coordinates X, Y, Z ms res	Ideas Inc. [103207696] SELECTED OPTIONS SELECTION Adjustment Metre 2 All 1-D, 2-D, and 3-D On Known 95.000 Off On All Iterations 5 Decimal Places On On On All Iterations	Page	1
GeoL	P: OPTION Computation Mo Linear Unit Maximum Iterat Confidence Reg Print Input St Variance Facto Confidence Lev Dual-Height Mo Print Solution Printed Ellips Print Adjusted Print Histogram Print Misclosu Print Residual:	Degrees of Freed 1985/86/87 BitWise SUMMARY OF de ions ions Selected ion Dimensions ation Data r Knowledge el for Statistics de Vector oidal Coordinates X, Y, Z ms res s	Ideas Inc. [103207696] SELECTED OPTIONS SELECTION Adjustment Metre 2 All 1-D, 2-D, and 3-D On Known 95.000 Off On All Iterations 5 Decimal Places On On On All Iterations All	Page	1
GeoL	ab - V1.82S, (C) P: OPTION Computation Mo Linear Unit Maximum Iterat Confidence Reg Print Input St Variance Facto Confidence Lev Dual-Height Mo Print Solution Printed Ellips Print Adjusted Print Histogra Print Misclosu Print Residual: Variance Facto	Degrees of Freed 1985/86/87 BitWise SUMMARY OF de ions ions Selected ion Dimensions ation Data r Knowledge el for Statistics de Vector oidal Coordinates X, Y, Z ms res s r Usage	Ideas Inc. [103207696] SELECTED OPTIONS SELECTION Adjustment Metre 2 All 1-D, 2-D, and 3-D On Known 95.000 Off On All Iterations 5 Decimal Places On On On All Iterations All Scale Confidence	Page	1
GeoL	ab - V1.82S, (C) P: OPTION Computation Mo Linear Unit Maximum Iterat Confidence Reg Confidence Reg Print Input St Variance Facto Confidence Lev Dual-Height Mo Print Solution Print Adjusted Print Histogram Print Misclosu Print Residual Variance Facto Residual Rejec	Degrees of Freed 1985/86/87 BitWise SUBMARY OF de ions ions Selected ion Dimensions ation Data r Knowledge el for Statistics de Vector oidal Coordinates X, Y, Z ms res s r Usage tion Criterion	Ideas Inc. [103207696] SELECTED OPTIONS SELECTION Adjustment Metre 2 All 1-D, 2-D, and 3-D On Known 95.000 Off On All Iterations 5 Decimal Places On On On All Iterations All Scale Confidence Tau Max	Page	1
GeoL	P: OPTION Computation Mo Linear Unit Maximum Iterat Confidence Reg Confidence Reg Print Input St Variance Facto Confidence Lev Dual-Height Mo Print Solution Print Adjusted Print Histogram Print Misclosu Print Residual Variance Facto Residual Rejec Angular Misclosu	Degrees of Freed 1985/86/87 BitWise SUMMARY OF de ions ions Selected ion Dimensions ation Data r Knowledge el for Statistics de Vector oidal Coordinates X, Y, Z ms res s r Usage tion Criterion sure Limit Factor	Ideas Inc. [103207696] SELECTED OPTIONS SELECTION Adjustment Metre 2 All 1-D, 2-D, and 3-D On Known 95.000 Off On All Iterations 5 Decimal Places On On On All Iterations All Scale Confidence Tau Max 10	Page	1
GeoL	P: OPTION Computation Mo Linear Unit Maximum Iterat Confidence Reg Print Input St Variance Facto Confidence Lev Dual-Height Mo Print Solution Print Adjusted Print Histogram Print Misclosu Print Residual: Variance Facto Residual Rejec Angular Misclosu Linear Misclosu	Degrees of Freed 1985/86/87 BitWise SUMMARY OF de ions ions Selected ion Dimensions ation Data r Knowledge el for Statistics de Vector oidal Coordinates X, Y, Z ms res s r Usage tion Criterion sure Limit Factor ure Limit Factor	Ideas Inc. [103207696] SELECTED OPTIONS SELECTION Adjustment Metre 2 All 1-D, 2-D, and 3-D On Known 95.000 Off On All Iterations 5 Decimal Places On On On All Iterations All Scale Confidence Tau Max 10 10	Page	1
GeoL	P: OPTION Computation Mo Linear Unit Maximum Iterat Confidence Reg Confidence Reg Print Input St Variance Facto Confidence Lev Dual-Height Mo Print Solution Print Adjusted Print Histogram Print Misclosu Print Residual Variance Facto Residual Rejec Angular Misclosu	Degrees of Freed 1985/86/87 BitWise SUMMARY OF de ions ions Selected ion Dimensions ation Data r Knowledge el for Statistics de Vector oidal Coordinates X, Y, Z ms res s r Usage tion Criterion sure Limit Factor ure Limit Factor	Ideas Inc. [103207696] SELECTED OPTIONS SELECTION Adjustment Metre 2 All 1-D, 2-D, and 3-D On Known 95.000 Off On All Iterations 5 Decimal Places On On On All Iterations All Scale Confidence Tau Max 10	Page	1

Figure D-12. GEOLAB adjustment output (constrained) (Sheet 1 of 7)

A= 6378137.0			4 X0= 0.0	100 YO=		
CODE IDENT.	DESCRIPTOR		INITIAL VALUES	i		
14 2006			•••••			
14 2000	ELL IDSOTOAL		39 11 34.37462	-123 10	10 28088	334 NR51
	ASTRONOMIC	•	30 11 34.37462	-123 10	1 10.20700	730.0050 1780 AFF
	CECIDAL	:	0 0 0 00000	. ,23 ,0	10.20700	0.000
	CARTESIAN	:	39 11 34.37462 0 0 0.00000 -2708280.4788	-414	3494.7721	4009147.893
		•	2,0020011100			400714.1070.
14 2013						
	ELLIPSOIDAL	. :	39 15 12.11624	-123 13	17.48887	222.8350
	ASTRONOM1C	:	39 15 12.11624 0 0 0.00000	-123 13	17.48887	222.8350
	GEOIDAL	:	0 0 0.00000	0 0	0.00000	0.0000
	CARTESIAN	:	-2709665.3418	-413	7409.4525	4014278.4657
14 2014						
	ELLIPSOIDAL	. :	59 7 57.41258	-123 12	14.77684	190.1700
	ASTRONOMIC	:	<i>59 7</i> 57.41258	-123 12	14.77684	190.1700
	GEOIDAL	:	39 7 57.41258 39 7 57.41258 0 0 0.00000 -2713032.7742	0 0	0.00000	0.0000
	CARTESIAN	:	-2713032.7742	-414	5500,4693	4003867.7960
2/ 2004						
24 2001	ELL TRANSPA	_	70 10 1/ /7/22	_077 44	4 /50/4	3/3 6/6/
	ELLIPSOIDAL		39 12 14.43422	-125 11	0.45941	243.8658
	ASTRONOMIC	•	39 12 14.43422	-125 11	0.45941	243.8658
	GEOIDAL	:	0 0 0.00000		0.00000	0.0000
	CAKTESTAN	:	-2708942.2350	-414	2043.8310	4010047.0300
24 2002						
24 2002	ELI IDENIDAL		39 11 37.00656	-127 11	ARC 30 0	243,8815
	ACTOMINATO	•	39 11 37.00636	-123 11	0.74200 0.06286	243,001.
	CENTRAL	:	0 0 0 00000	0 0	0.74200	0.000
	CARTESIAN	:	39 11 37.00656 0 0 0.00000 -2709230.7400	-414	2726 8330	4009152.5340
	urm i E G A FIN	•	2. 4725017400	717		-00713213340
94 WGSXX						
	3DO SCAL	:	0.00000			
	3DD ROTX					
	300 ROTY	:				
	3DD ROTZ		0.00000			
GETUP success	fully complet	ed.				
GeoLab - V1 A	25. (C) 1985/	8678	7 BitWise Ideas	Inc. 11	032076961	Page
			6: Reordering w	as done.		_
AT TO	N OBS TYPE		OBSER	VATION	APPROX.SIG.	MISCLOSURE
2001 2006	3-D X-Co	ord I	Diff 66 Diff -144	6.6170	0.0037	-4.8608
2001 2006	3-D Y-Co	ord	Diff -144	1.5480	0.0045	
2001 2006	3-D Z-Co	ord I	Diff -90	8.2800	0.0028	
2002 2006				3.2950	0.0022	-3.0338
2002 2006	_			8.3180	0.0044	-19.6211
2002 2006	3-D Z-Co	ord I		6.7100	0.0029	12.0693
2001 2002		ord	Diff -28	6.6690	0.0024	-1.8360
2001 2002		ord		3.2190	0.0026	10.2170
2001 2002	3-D Z-Co	ord I	Diff -89	1.5890	0.0025	-2.9070
2001 2002	3-D X-Co	ord I	Diff -28	6.6790	0.0026	-1.8260
2001 2002	3-D Y-Co	ord I	D1ff -69	3.2230	0.0030	10.2210
2001 2002	3-D Z-Co	ord	Diff -89	1.5780	0.0026	-2.9180
2014 2002				9.0050	0.0129	3.0292
2014 2002				4.0180	0.0101	19.6183
2014 2002				6.7980	0.0113	-12.0600
2013 2001				8.2440	0.0059	4.8628
2013 2001				3.7750	0.0083	9.3965
				2.2870	0.0059	-9.1487
2013 2001	70400	· · ·				

Figure D-12. (Sheet 2 of 7)

\=	6378137.	000 B= 6356	752.31	4 X	AM ADJUSTME 1.0 =0	NT NAD-83 000 YO= (0.000 z	.0 0.0
		Solution (II	eratio	on C	ount = 1):			
COD	E IDENT.	TYPE			INITIAL	DX		UPDATE
24	2001	LATITUDE	39	12	14.43422	0.01413	39	12 14.4483
24	2001	LONGITUDE	-123	11	6.45941	0.01413 0.04476	-123	11 6.4146
24	2001	HEIGHT			243.86577	13.93968		257.8054
24	2002	LATITUDE	39	11	37.00656	-0.06729	39	11 36.9392
24	2002	LONGITUDE	-123	11	0.94286	0.34171	-123	11 0,6011
24	2002	HEIGHT			243.88154	-0.06729 0.34171 21.63406		265.5156
94	WGSXX	300 SCAL 30D ROTX 30D ROTY 30D ROTZ			0.00000	-0.00161 0.03270		-0.0016
94	WGSXX	3DD ROTX			0.00000	0.03270		0.0327
94	WGSXX	3DD ROTY			0.00000	-0.06406		-0.0640
94 OL1	WGSXX Æ succes	3DD ROTZ sfully compl	eted.		0.00000	-0.04338		-0.04338
	·				itWise Ideas	s Inc. [1032076	96]	Page
	• • • • • • • • • • • • • • • • • • • •							
eol	.ab - V1.	82s, (C) 198	5/86/8	7 B	itWise Ideas	inc. [1032076	96]	Page
		••••				·••··		
OLY	Æ:	Adjuste	d Valu	es (Iteration C	ount = 2):		
					INITIAL	Ount = 2):		ADJUSTEL
		LATITUDE						
14	2006	LONGITUDE	-123	10	10.28988	FIXED		
14	2006	HEIGHT			336.08500	FIXED		
		LATITUDE	39	15	12.11624	FIXED		
14	2013	LONGITUDE	-123	15 13	17.48887	FIXED		
14	2013	LATITUDE LONGITUDE HEIGHT	-123	15 13	12.11624 17.48887 222.83500	FIXED		
14 14 14	2013 2013 2014	LONGITUDE HEIGHT LATITUDE	-123 39	13	17.48887 222.83500 57.41258	FIXED FIXED		
14 14 14 14	2013 2013 2014 2014	LONGITUDE HEIGHT LATITUDE	-123 39	13	17.48887 222.83500 57.41258	FIXED FIXED		
14 14 14 14	2013 2013 2014	LONGITUDE HEIGHT LATITUDE	-123 39	13	17.48887 222.83500	FIXED FIXED		
14 14 14 14 14 14	2013 2013 2014 2014 2014 2001	LONGITUDE HEIGHT LATITUDE LONGITUDE REIGHT LATITUDE	-123 39 -123	13 7 12	17.48887 222.83500 57.41258 14.77684 190.17000 14.44836	FIXED FIXED FIXED FIXED FIXED 0.00000	39	12 14.44836
14 14 14 14 14 24 24	2013 2013 2014 2014 2014 2001 2001	LONGITUDE MEIGHT LATITUDE LONGITUDE KEIGHT LATITUDE LONGITUDE	-123 39 -123	13 7 12	17.48887 222.83500 57.41258 14.77684 190.17000 14.44836 6.41465	FIXED FIXED FIXED FIXED 0.00000 0.00000	39 -123	11 6.41465
14 14 14 14 14 24 24	2013 2013 2014 2014 2014 2001	LONGITUDE HEIGHT LATITUDE LONGITUDE REIGHT LATITUDE	-123 39 -123	13 7 12	17.48887 222.83500 57.41258 14.77684 190.17000 14.44836	FIXED FIXED FIXED FIXED FIXED 0.00000 0.00000	39 -123	
14 14 14 14 14 14 24 24 24 24	2013 2013 2014 2014 2014 2001 2001 2001 2001	LONGITUDE MEIGHT LATITUDE LONGITUDE KEIGHT LATITUDE LONGITUDE HEIGHT LATITUDE	-123 39 -123	13 7 12	17.48887 222.83500 57.41258 14.77684 190.17000 14.44836 6.41465	FIXED FIXED FIXED FIXED 0.00000 0.00000	39 -123 39	11 6.41465
14 14 14 14 14 14 24 24 24 24	2013 2013 2014 2014 2014 2001 2001 2001 2002 2002	LONGITUDE MEIGHT LATITUDE LONGITUDE KEIGHT LATITUDE LONGITUDE HEIGHT LATITUDE LONGITUDE LONGITUDE	-123 -123 -123 -123	13 7 12 12	17.48887 222.83500 57.41258 14.77684 190.17000 14.44836 6.41465 257.80545 36.93927 0.60115	FIXED FIXED FIXED FIXED 0.00000 0.00000 -0.00000 -0.00000	-123	11 6.41465 257.80545
14 14 14 14 14 14 24 24 24 24	2013 2013 2014 2014 2014 2001 2001 2001 2001	LONGITUDE MEIGHT LATITUDE LONGITUDE KEIGHT LATITUDE LONGITUDE HEIGHT LATITUDE	-123 39 -123 39 -123	13 7 12 12 11	17.48887 222.83500 57.41258 14.77684 190.17000 14.44836 6.41465 257.80545 36.93927	FIXED FIXED FIXED FIXED 0.00000 0.00000 -0.00000	-123 39	11 6.41465 257.80545 11 36.93927
14 14 14 14 14 14 14 24 24 24 24 24 24	2013 2013 2014 2014 2014 2001 2001 2001 2002 2002	LONGITUDE MEIGHT LATITUDE LONGITUDE KEIGHT LATITUDE LONGITUDE HEIGHT LATITUDE LONGITUDE LONGITUDE	-123 39 -123 39 -123	13 7 12 12 11	17.48887 222.83500 57.41258 14.77684 190.17000 14.44836 6.41465 257.80545 36.93927 0.60115	FIXED FIXED FIXED FIXED 0.00000 0.00000 -0.00000 -0.00000	-123 39	11 6.41465 257.80545 11 36.93927 11 0.60115
14 14 14 14 14 24 24 24 24 24 24 24 24	2013 2013 2014 2014 2014 2001 2001 2001 2002 2002	LONGITUDE MEIGHT LATITUDE LONGITUDE REIGHT LATITUDE LONGITUDE HEIGHT LATITUDE LONGITUDE HEIGHT 3DD SCAL 3DD ROTX	-123 39 -123 39 -123	13 7 12 12 11	17.48887 222.83500 57.41258 14.77684 190.17000 14.44836 6.41465 257.80545 36.93927 0.60115 265.51561 -0.00161 0.03270	FIXED FIXED FIXED FIXED 0.00000 0.00000 -0.00000 0.00000 0.00000 0.00000 0.00000	-123 39	11 6.41465 257.80545 11 36.93927 11 0.60115 265.51561 -0.00161 0.03270
14 14 14 14 14 14 14 24 24 24 24 24 24	2013 2013 2014 2014 2014 2001 2001 2001 2002 2002	LONGITUDE HEIGHT LATITUDE LONGITUDE HEIGHT LATITUDE LONGITUDE HEIGHT LATITUDE LONGITUDE HEIGHT 3DD SCAL	-123 39 -123 39 -123	13 7 12 12 11	17.48887 222.83500 57.41258 14.77684 190.17000 14.44836 6.41465 257.80545 36.93927 0.60115 265.51561 -0.00161	FIXED FIXED FIXED FIXED 0.00000 0.00000 -0.00000 0.00000 0.00000	-123 39	11 6.41465 257.80545 11 36.93927 11 0.60115 265.51561 -0.00161

Figure D-12. (Sheet 3 of 7)

### Adjusted Cartesian Coordinates: COOR IDENT								
24 2001 -2708947-0978 -4142053.2284 4010056.1788 24 2002 -2709233.7715 -4142746.4512 4009164.5972 SOLVE successfully completed. Geolab - V1.82S, (C) 1985/86/87 BitWise Ideas Inc. [103207696] Page 8 INVERT: INVERT successfully completed. Geolab - V1.82S, (C) 1985/86/87 BitWise Ideas Inc. [103207696] Page 9 RESID: STATION 3-D COORD DIFFS STD.DEV. RESIDUAL STD.DEV. STAN.RES. 2001 -2708942.2350 -4142043.B310 4010047, 0300 -0.0050 -0.0020 -0.0041 0.4845 -4143485.3790 0.0060 0.0043 0.0045 0.9530 4009138.7500 0.0060 0.0043 0.0045 0.9530 4009138.7500 0.0060 0.0043 0.0045 0.9530 4009135.2340 0.0060 -0.0055 0.00226 -2.1060			Adj	usted Carte	sian Coordin	nates:		
24 2002	24 200	NT.	X-COORD I	NATE	Y-COORDINATE			
SOLVE successfully completed. Page 8	24 2007	1 -	2708947. 2709233.	0978 - 7715 -	4142053.2284 4142746.4512	40100	56.1788	
INVERT: INVERT successfully completed. GeoLab - V1.82S, (C) 1985/86/87 BitWise Ideas Inc. [103207696] Page 9 RESID: STATION 3-D COORD DIFFS STD.DEV. RESIDUAL STD.DEV. STAN.RES. 2001 -2708942.2350 -4142043.8310 4010047.0300 2006 -2708275.6180 0.0050 0.0020 0.0041 0.4865 -4143485.3790 0.0060 0.0043 0.0045 0.9530 4009138.7500 0.0040 -0.0055 0.0026 -2.1060 ==================================	SOLVE SU							
RESID: STATION 3-D COORD DIFFS STD.DEV. RESIDUAL STD.DEV. STAN.RES. 2001 -2708942.2350 -4142043.8310 401047.0300 2006 -2708275.6180 0.0050 0.0043 0.0045 0.9530 409138.7500 0.0040 0.0055 0.0026 2.1060 -2709230.7400 -4142726.8330 4009132.5340 2006 -2708277.4450 0.0050 0.0030 0.0032 0.0045 -4143475.1510 0.0050 0.0031 0.0032 0.0050 -414276.8330 4009135.8240 0.0040 0.0063 2002 -270827.4450 0.0050 0.0031 0.0032 0.0050 -414276.8330 -409138.8200 0.0040 0.0063 2002 0.0060 0.0060 0.0060 0.0060 0.0060 -414276.8330 0.0060	GeoLab -	V1.82S, (C)	1985/86	/87 BitWise	Ideas Inc.	[103207696]	Page	8
RESID: STATION 3-D COORD DIFFS STD.DEV. RESIDUAL STD.DEV. STAN.RES. 2001 -2708942.2350	INVERT:	INV	ERT succ	essfully co	mpleted.			
RESID: STATION 3-D COORD DIFFS STD.DEV. RESIDUAL STD.DEV. STAN.RES. 2001 -2708942.2350	GeoLab -	V1.82S. (C)	1985/86	/87 BitWise	Ideas Inc.	[103207696]	Page	9
2001 -2708942.2350 -4142043.8310 4010047.0300 2006 -2708275.6180 0.0050 0.0020 0.0041 0.4865 -4143485.3790 0.0060 0.0043 0.0045 0.9530 4009138.7500 0.0040 -0.0055 0.0026 -2.1060 -2708277.4050 0.0050 -0.0055 0.0026 -2.1060 -4142726.8330 4009152.5340 2006 -2708277.4450 0.0030 -0.0024 0.0016 -1.5309 -4143475.1510 0.0050 -0.0031 0.0032 -0.9650 4009138.8240 0.0040 0.0063 0.0026 2.3907 -2708247.4450 0.0040 0.0063 0.0026 2.3907 -2708247.450 0.0040 0.0063 0.0026 2.3907 -2708247.450 0.0040 0.0063 0.0026 2.3907 -2708247.450 0.0040 0.0063 0.0026 2.3907 -2708247.450 0.0040 0.0036 0.0031 -1.1706 4040040.8370 0.0040 0.0040 0.0031 0.0032 2.2786 -142743.8510 0.0040 0.0072 0.0032 2.2786 -2709242.7860 0.0040 0.0072 0.0032 2.2786 -2709242.7870 0.0040 0.0072 0.0032 2.2786 -414274.4410 0.0040 0.0072 0.0032 0.0031 0.1285 4009148.3720 0.0040 0.0054 0.0031 0.1285 4009148.3720 0.0040 0.0004 0.0031 0.1285 4009148.3720 0.0040 0.0004 0.0031 0.1285 -4142732.8130 0.0040 0.0035 0.0149 -0.2328 -4142732.8130 0.0160 -0.0035 0.0149 -0.2328 -4142732.8130 0.0160 -0.0035 0.0149 -0.2328 -4142732.8130 0.0160 -0.0015 0.0090 -0.1659 -4137421.4500 -4137421.4500 -414233.6620 -2713031.0290 0.0150 -0.0018 0.0105 -0.1739 -4143312.4700 0.0460 0.0055 0.0419 0.1303			•••••					
-4142043.8310 4010047.0300 2006 -2708275.6180	STATION	3-D COORD	DIFFS	STD.DEV.	RESIDUAL	STD.DEV.	STAN.RES.	
A010047,0300	2001				***************************************			
2006								
2002 -2709230.7400 -4142726.8330 4009152.5340 2006 -2708277.4450	2006	-270827	5.6180	0.0050	0.0020	0.0041	0.4865	
2002		-414348	5.379 0	0.0060	0.0043	0.0045	0.9530	
2002 -2709230.7400 -4142726.8330 4009152.5340 2006 -2708277.4450		400913	8.7500	0.0040	-0.0055	0.0026	-2,1060	
-4142726.8330 4009152.5340 2006 -2708277.4450				end of oose	ivacion sec			
2006								
-4143475.1510		400915	2.5340				4 5700	
2001 -2708941.0950 -4142743.8510	2006		7.4450 E 1510	0.0030	-0.0024	0.0016	-1.5309 -0.0650	
2001 -2708941.0950 -4142743.8510			5.1310	0.0030	0.0063	0.0026	2.3907	
-4142050.6320 4010040.8370 2002 -2709227.7640								
2002	2001							
2002								
4009149.2480	2002	-270922	7.7640	0.0030	-0.0046	0.0020	-2.2625	
2001 -2708946.1080 -4142048.2180 4010039.9500 2002 -2709232.7870 0.0040 0.0054 0.0033 1.6090 -4142741.4410 0.0040 0.0004 0.0031 0.1285 4009148.3720 0.0040 -0.0038 0.0032 -1.1993 ==================================	•			0.0040	-0.0036	0.0031	-1.1706	
2001 -2708946.1080 -4142048.2180 4010039.9500 2002 -2709232.7870								
-4142048.2180 4010039.9500 2002 -2709232.7870				end of Just	ervation set			
2002 -2709232.7870	L 001							
-4142741.4410							4 (000	
4009148,3720	2002				0.0054	0.0055		
2014 -2713050.5170 -4145286.8310 4003867.5850 2002 -2709251.5120		400914	8.3720		-0.0038	0.0032		
-4145286.8310 4003867.5850 2002 -2709251.5120	=======		======					
2002	2014	_						
2002 -2709251.5120 0.0180 -0.0035 0.0149 -0.2328 -4142732.8130 0.0160 -0.0015 0.0090 -0.1659 4009164.3830 0.0200 0.0047 0.0141 0.3373								
-4142732.8130	2002	, , , , , ,		0.0180			-0.2328	i
2013 -2709663.6000 -4137421.4500 4014263.6620 2014 -2713031.0290 0.0150 -0.0018 0.0105 -0.1739 -4145312.4700 0.0460 0.0055 0.0419 0.1303								
2013 -2709663.6000 -4137421.4500 4014263.6620 2014 -2713031.0290 0.0150 -0.0018 0.0105 -0.1739 -4145312.4700 0.0460 0.0055 0.0419 0.1303								
-4137421.4500 4014263.6620 2014 -2713031.0290 0.0150 -0.0018 0.0105 -0.1739 -4145312.4700 0.0460 0.0055 0.0419 0.1303				End of Obse	ervation Set	eccarrents:	*********	====
4014263.6620 2014 -2713031.0290 0.0150 -0.0018 0.0105 -0.1739 -4145312.4700 0.0460 0.0055 0.0419 0.1303	2013							
-4145312.4700 0.0460 0.0055 0.0419 0.1303								
	2014							
4003636.7679 0.0330 0.0010 0.0673 0.0344								
		40038	2.989U	0.0550	0.0010	0.0293	0.0344	•

Figure D-12. (Sheet 4 of 7)

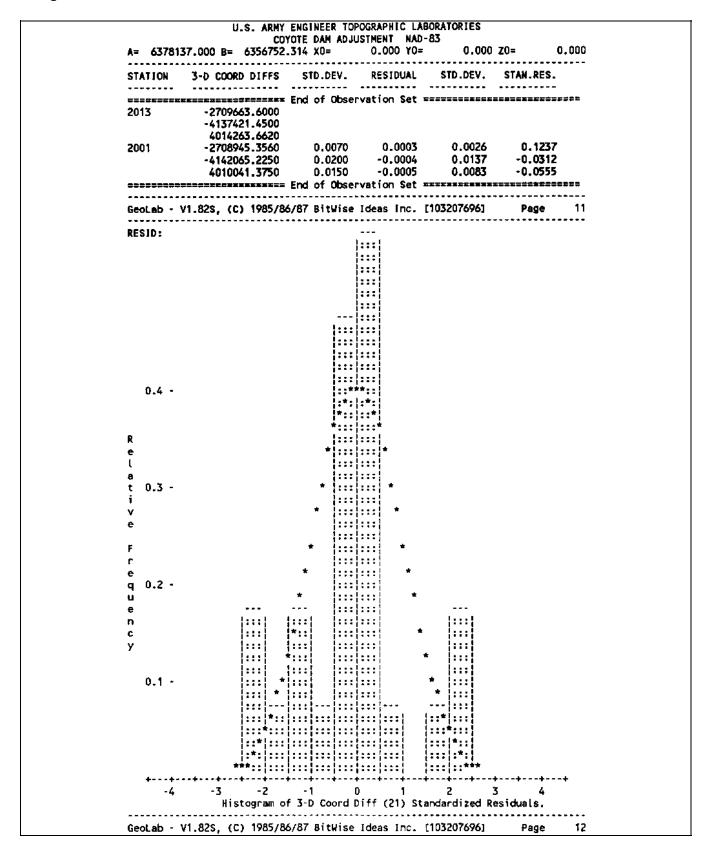


Figure D-12. (Sheet 5 of 7)

	137.000 B= 6330722.314 AU-	0.000 YO= 0.000 ZO=	0.000
RESID:			
	STATISTICS	SUMMARY	İ
			.
	+		i
	esidual Critical Value Type	Tau Max	
	esidual Critical Value onvergence Criterion	2.7083 0.001000	į
	inal Iteration Counter Value	2	į
-	onfidence Level Used	95.0000 0	•
	umber of Flagged Residuals : stimated Variance Factor :	1.0944	ļ
	umber of Degrees of Freedom	11	į
			ļ
į	Chi-Square Test on t	he Variance Factor:	į
	5.4919e-001 < 1.00	00 < 3.1549e+000 ?	į
į	2.00		į
	THE TEST	PASSES.	į
	uccessfully completed. - V1.82S, (C) 1985/86/87 BitWise	1deas Inc. [103207696] Pag	e 13
	· V1.82S, (C) 1985/86/87 BitWise		e 13
GeoLab	· V1.82S, (C) 1985/86/87 BitWise	mputed using the following factor	
GeoLab	V1.82S, (C) 1985/86/87 BitWise	mputed using the following facto	
GeoLab	V1.82S, (C) 1985/86/87 BitWise	mputed using the following facto	
GeoLab	V1.82S, (C) 1985/86/87 BitWise All confidence regions were co	mputed using the following factor 1.09438 1.09438 1.960	
GeoLab	V1.82S, (C) 1985/86/87 BitWise All confidence regions were co Variance factor used = Estimated variance factor = 1-D expansion factor = 2-D expansion factor =	nputed using the following factor 1.09438 1.09438 1.960 2.448	
GeoLab	V1.82S, (C) 1985/86/87 BitWise All confidence regions were co Variance factor used = Estimated variance factor = 1-D expansion factor =	mputed using the following factor 1.09438 1.09438 1.960	
GeoLab	All confidence regions were convariance factor used = Estimated variance factor = 1-D expansion factor = 3-D expansion factor = Note that, for relative confidence =	nputed using the following factor 1.09438 1.09438 1.960 2.448 2.795 Hence regions, precisions are major semi-axis and the spatial	rs:
GeoLab	V1.82S, (C) 1985/86/87 BitWise All confidence regions were co Variance factor used = Estimated variance factor = 1-D expansion factor = 2-D expansion factor = Note that, for relative confidence between the two static Error ellipses for which all co	mputed using the following factor 1.09438 1.09438 1.960 2.448 2.795 Hence regions, precisions are major semi-axis and the spatial ons.	rs:

Figure D-12. (Sheet 6 of 7)

A= 6378°	137.000 В	= 6356752	YOTE DAM A .314 XO=	MEMTRULD. 0.0	17 NAD 100 YO=	-83	0.000	ZO=	0	0.000
ELLIPSE:		ALI	XILIARY PA	RAMETER	CONFID	ENCE II	NTERVAL	s (9	5.000	X):
IDENT.		CLASS								
UGSYY	300	SCAL		0.0016		1.1261				
MOSKA	, 500	SCAL ROTX ROTY	0 0	0.03	0 0	0.82				
		ROTZ	0 0	-0.04	0 0	1.37	,			
GeoLab -	V1.82S,	(C) 1985/8	6/87 BitWi		inc.	[10320	7696)	P	age	15
		2-D AND 1-I				-				
IDENT.		SEMI-AXIS								
2001		0.0066 0.0062		0.0048	107.2	22	0. n	0133 0127		
2002				• • • • • • • •						44
GeoLab -	V1.82S,	(C) 1985/8	6/87 BitW	ise Idea	s Inc.	[10320	7090]	٠	age	
FROM	TÖ	MAJ.SEMI	MIN.SEMI	AZ(MAJ)	VERTICA		IAL DIS	iT.	PREC	ISION
FROM 2001	TO 2002	MAJ.SEMI 0.0045	0.0036	AZ(MAJ) 108.07	VERTICA 0.000	AL SPAT	TAL DIS	ST.	PREC:	ISION 6 PPM
FROM 2001	TO 2002	MAJ.SEMI	0.0036	AZ(MAJ) 108.07	VERTICA 0.000	AL SPAT	TAL DIS	ST.	PREC:	ISION 6 PPM
FROM 2001 GeoLab	TO 2002 V1.82S,	MAJ.SEMI 0.0045 (C) 1985/8 3-D STATIO	0.0036 0.6/87 Bitw	108.07 ise Idea	0.000 s Inc.	AL SPAT 82 (10320	1165.18 1165.18 07696]	856 	PREC 3.844 Page	6 PPM
FROM 2001 GeoLab	TO 2002 V1.82S,	MAJ.SEMI 0.0045 (C) 1985/8 3-D STATIO	0.0036 0.6/87 Bitw	108.07 ise Idea	0.000 s Inc.	AL SPAT 82 (10320	1165.18 1165.18 07696]	856 	PREC 3.844 Page	1510N 6 PPM 17
FROM 2001 GeoLab	T0 2002 V1.82S,	MAJ.SEMI 0.0045 (C) 1985/8 3-D STATIO MAJOR SEMI	0.0036 0.0036 86/87 Bitw M CONFIDE	108.07 ise Idea	0.000 s Inc.	82 (10320 95.000 :	1165.18 1165.18 076961	ST. SS6	PREC 3.844 Page SEMI-	AXIS
FROM 2001 GeoLab - ELLIPSE: IDENT.	T0 2002 V1.82S,	MAJ.SEMI 0.0045 (C) 1985/8 3-D STATIO MAJOR SEMI	0.0036 0.0036 36/87 Bitw W CONFIDE (-AXIS	108.07 ise Idea MCE REGIO MEDIU	O.OORS (S	82 (10320 95.000: -AXIS	1165.18 176961 X):	556 556 41NOR	PREC 3.844 Page SEMI-	1510N 6 PPM 17 17 AXIS 0056 2.3
FROM 2001 GeoLab - ELLIPSE: IDENT. 2001 2002	TO 2002 V1.82\$,	MAJ.SEMI 0.0045 (C) 1985/8 3-D STATIO MAJOR SEMI	0.0036 0.0036 36/87 BitW W COMFIDE (-AXIS 0.0191 = 81.9 0.0182 = 87.6	AZ(MAJ) 108.07 ise Idea MCE REGIO MEDIU A=27 A=30	0.000 s Inc. DNS (9 M SEMI 0.0 V =	AL SPAT 82 (10320 95.000 -AXIS .0070 7.8 .0070 1.9	1165.18 1165.18 17696]	41NOR 41NOR 4= 0	PREC 3.844 Page SEMI-	1510N 6 PPM 17 17 AXIS 0056 2.3 0051
FROM 2001 GeoLab - ELLIPSE: IDENT. 2001 2002 GeoLab -	T0 2002 V1.82S,	MAJ.SEMI 0.0045 (C) 1985/8 3-D STATIO MAJOR SEMI (A=106.6 V= (A= 90.0 V= (C) 1985/8	0.0036 0.0036 36/87 Bitw N CONFIDE (-AXIS 0.0191 = 81.9 0.0182 = 87.6	AZ(MAJ) 108.07 ise Idea MEDIU A=27 A=30	0.000 s Inc. ONS (9 M SEMI 0.00 V= 0.00 V= s Inc.	AL SPAT 82 (10320 95.000 -AXIS .0070 7.8 .0070 1.9	1165.18 1165.18 076961 X) :	41NOR 4= 0, 4=216	PREC 3.844 Page SEMI- 0.1 3 V= 0.2 V= Page	1510N 6 PPM 17 17 AXIS 0056 2.3 0051
FROM 2001 GeoLab - ELLIPSE: IDENT. 2001 2002 GeoLab -	TO 2002 V1.82\$,	MAJ.SEMI 0.0045 (C) 1985/8 3-D STATIO MAJOR SEMI (A=106.6 V= (A= 90.0 V= (C) 1985/8	0.0036 0.0036 36/87 BitW WE STATIO	AZ(MAJ) 108.07 ise Idea MEDIU A=27 A=30 ise Idea	0.000 s Inc. 0.000 s Inc. 0.000 s Inc. 0.000 c Semi	AL SPAT 82 (10320 95.000 -AXIS .0070 7.8 .0070 1.9 (10320	1165.18 1165.18 07696] X):	41NOR 41NOR 4= 0. 4=216	PREC 3.844 Page SEMI- 0,.3 V= 02 V=	AXIS 0056 2.3 0051 1.4
FROM 2001 GeoLab - ELLIPSE: IDENT. 2001 2002 GeoLab - ELLIPSE: FROM	TO 2002 V1.82\$, V1.82\$,	MAJ.SEMI 0.0045 (C) 1985/8 3-D STATIO MAJOR SEMI (A=106.6 V= (C) 1985/8 3-D RELATI MAJOR-SEI	0.0036 0.0036 0.0036 0.0081 0.0081 0.0191 0.0182 0.0182 0.0182 0.0182 0.0182	AZ(MAJ) 108.07 ise Idea MCE REGIO MEDIU A=27 A=30 ise Idea	VERTICA 0.000 s Inc. DNS (S M SEMI 0.0 V 0 6.2 V s Inc.	AL SPAT 82 (10320 95.000 -AXIS .0070 7.8 .0070 1.9 (10320	1165.18 17696] X): 076961 (95.00	41NOR 41NOR 4= 0. 4=216	PREC 3.844 Page SEMI - 0.13 V= 0.2 V= Page	1510N 6 PPM 17 17 AXIS 0056 2.3 0051 1.4
FROM 2001 GeoLab ELLIPSE: 1DENT. 2001 2002 GeoLab ELLIPSE: FROM 2001	TO 2002 V1.82S, V1.82S, TO 2002	MAJ.SEMI 0.0045 (C) 1985/8 3-D STATIO MAJOR SEMI (A=90.0 V= (C) 1985/8 3-D RELATI MAJOR-SEI 0.01	0.0036 0.0036 0.0036 0.0036 0.0091 0.0191 0.0182 0.0182 0.0182 0.0182 0.0182 0.0182 0.0182 0.0182 0.0182	AZ(MAJ) 108.07 ise Idea MCE REGIO MEDIU A=27 A=30 ise Idea	0.000 s Inc. 0.000 s Inc. 0.008 (9 0.002 c 1000 c 2 V=	AL SPAT 82 (10320 -AXIS .0070 7.8 .0070 1.9 (10320	1165.18 17696] X): 076961 (95.00	41NOR 41NOR 4= 0. 4=216	PREC 3.844 Page SEMI - 0.13 V= 0.2 V= Page	1510N 6 PPM 17 17 AXIS 0056 2.3 0051 1.4

Figure D-12. (Sheet 7 of 7)

(1:10,000). The relative line accuracy between 2001 and 2002 on the constrained adjustment was 3.846 ppm, or 1:260,000. This indicates excellent connections with existing control.

- d. The variance factor shown on page 14 of each adjustment is within acceptable limits (0.5 to 1.5). As such, it could be used to determine outlier limits for rejection of data, as explained in Chapter 11.
- e. The residual corrections to each baseline component are shown on page 10 of each adjustment. Special review is made of the standardized residuals, which one will find is approximately comparable to normalized residuals in GEOLAB software. None of the residuals were flagged (based on Tau Max testing) for exceeding tolerance.
- f. The 3D positional and relative confidence regions (ellipsoid) and 3D line accuracy precessions are shown at the end of each adjustment. These statistics are not applicable for most USACE work.
- g. Of all the output statistics, only the residuals, standardized residuals, relative 2D/1D line precessions, and variance factor have useful application for USACE work. The histograms, Chi-square tests, 3D ellipsoid, etc. are useful only if one understands their derivation and application.
- h. The results of the free and constrained adjustments in this example were not significantly different. This is usually not the case -- typically, station/line accuracies degrade on the constrained adjustment.

Section II Survey No. 2: Precise Control Survey (Dworshak Dam, Idaho)

D-7. General

A high precision GPS control survey may be performed at sites for structural deformation monitoring. Accurate control in the vicinity of the structure is critical. Absolute NGRS coordinate on monitoring points is of lesser importance. NGRS control may be brought into one of the reference points with GPS. Only the NGRS coordinates of this fixed point are held fixed for all subsequent adjustments in the vicinity of the structure.

D-8. Project Description

Survey example No. 2 was conducted in the vicinity of Dworshak Dam, Idaho. A diagram of the project is shown in Figure D-13. Baseline data from the NGRS control to one point (Fish Hatchery - 4001) at the project site were collected and other baseline data for baselines between 4001, Big Eddy (4002), and four points on the Dworshak Dam and Reservoir (4003, 4004, 4005, and 4006) as shown in Figure D-14. Loop closure checks were done for the complete network by using the loop closure routine shown in Figure D-15. The resultant precision for the loop is 0.43 ppm (1:2,300,000).

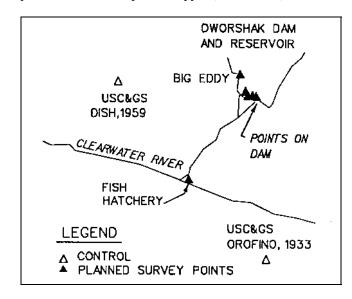


Figure D-13. Dworshak Dam and Project area

D-9. Adjustment

- a. An IOB file for the adjustment based on the formulated baselines was set up. Station USC&GS Dish, 1959, and USC&GS Orofino, 1933, were held fixed to establish NGRS control on Corps of Engineers Station 4001 at the project site. Then, for the next adjustment, 4001 was held fixed to adjust station 4002, 4003, 4004, 4005, and 4006. This free adjustment is shown in Figure D-16. Analysis of the adjustment was done as in Survey No. 1 and detailed in Chapter 11.
- *b.* The resultant adjustment statistics are shown on page 14 of Figure D-16. The 2D station confidence is on the order of 0.04 m (2DRMS) and ± 0.06 m in the vertical. The largest line accuracy is 36.322 ppm (1:27,000)

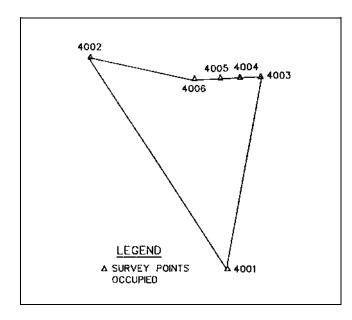


Figure D-14. GPS project diagram (Dworshak)

over a short (62 m) baseline. This would be acceptable even though a 1:100,00 relative accuracy is required. Due to fixed centering errors, maintaining 1:100,000 relative accuracies over lines less than 200 to 500 m is unrealistic.

Section III

Survey No. 3: Upper Saginaw River Control Project. (Saginaw, Michigan).

D-10. Planning Phase

- a. The GPS survey was planned for 24-25 March 1993, Julian day 083 and 084 in the vicinity of Saginaw, Michigan.
- b. This project was to establish Second-Order control, using GPS, at the Upper Saginaw River. The project area covered from Green Point down to the railroad bridge of the upper end of the condition survey project area, see Figure D-17. These control stations were to

Trimble Loop Closure Utility	
Start Traverse at Station: 4006 Starting Coords : 46x30'56.88832"@N 116x17'48.33684"@W	489.843
Baseline 1 File Name: 06053001.FIX From Station: 4006 To Station: 4005 Distance Travelled (m): 82.829 Current Coorda: 46x30'55.20552"@N 115x17'46.75486"@W	500.412
Baseline 2 File Name: 05042993.FIX From Station: 4005 To Station: 4004 Distance Travelled (m): 124.262 Current Coords : 46x30'54.30015"@N 116x17'44.23756"@W	489.809
Baseline 3 File Name: 04032981.FIX From Station: 4004 Distance Travelled (m): 214.384 Current Coords: 46x30'51.68841"ØN 116x17'42.38493"ØN	497.376
Baseline 4 File Name: 01032992.FIX From Station: 4003 Distance Travelled (m): 2872.755 Current Coords : 46x30'05.98881"ØN 116x19'27.67811"ØW	308.887
Baseline 5 File Name: 01023012.FIX From Station: 4001 Distance Travelled (m): 6122.840 Current Coords : 46x31'41.46032"ØN 116x18'24.06337"ØW	490.035
Baseline 6 File Name: 02063001.FIX From Station: 4002 To Station: 4006 Distance Travelled (m): 7695.981 Current Coords : 46x30'56.88826"ØN 116x17'48.33690"ØN	489.941
End Traverse at Station: 4006 Distance Travelled (m): 7695.981 Precision (ppm): dx: -0.001 dy: 0.001 dz: -0.003 dh: Ending Coords: 46x30'56.88826"BN 116x17'48.33690"GW Reference Coords: 46x30'56.88832"GN 116x17'48.33684"GW	0.43 -0.002 489.941 489.943

Figure D-15. Loop closure (Dworshak)

U.S. ARMY ENGINEER TOPOGRAPHIC LABORATORIES

DWORSHAK DAM

A= 6378137.000 B= 6356752.314 X0= 0.000 Y0= 0.000 Z0= 0.000 PREPARE:

ASCII input file: <wal 1.iob>.

PREPARE successfully completed.

GeoLab-V1.82S, (C) 1985/86/87BitWise Ideas Inc.[103207687] Page 0

U.S. ARMY ENGINEER TOPOGRAPHIC LABORATORIES
DWORSHAK DAM

A= 6378137.000 B= 6356752.314 X0= 0.000 Y0= 0.000 Z0= 0.000GETUP:

PARAMETERS	3	OBSERVATIO)NS
Description	Number	Description {	Number
All Stations Fixed Stations Free 3-D Stations Free 2-D Stations Coord. Parameters Astro. Latitudes Astro. Longitudes Geoid Records All Aux. Pars. Direction Pars. Scale Parameters Constant Pars. Rotation Pars. Translation Pars.	6 1 5 0 0 15 0 0 0 0 0 0	Directions Distances Azimuths Vertical Angles Zenithal Angles Angles Heights Height Difference Auxiliary Params. 2-D Coords. 2-D Coords. 3-D Coords. 3-D Coord. Diffs. Total Observations	00 00 00 00 60
De	grees of Fre	edom = 45	

GeoLab-V1.82S, (C) 1985/86/87BitWise Ideas Inc.[103207687] Page 1

Figure D-16. GEOLAB adjustment output (Sheet 1 of 8)

U.S. ARMY ENGINEER TOPOGRAPHIC LABORATORIES

DWORSHAK DAM

A= 6378137.000 B= 6356752.314 X0= 0.000 Y0= 0.000 Z0= 0.000 **GETUP** SUMMARY OF SELECTED OPTIONS OPTION SELECTION Computation Mode Linear Unit Adjustment Metre Linear Unit
Maximum Iterations
Confidence Regions Selected
Confidence Region Dimensions
Print Input Station Data
Variance Factor Knowledge
Confidence Level for Statistics
Dual-Height Mode
Print Solution Mode
Print Solution Mode
Print Adjusted X, Y, Z
Print Histograms
Print Misclosures
Print Residuals
Variance Factor Usage
Residual Rejection Criterion
Angular Misclosure Limit Factor
Linear Misclosure Limit Factor
Convergence Criterion All $\overline{\text{1-D}}$ and 2-D only Off Known 95.000 Off Only Adjusted Values 5 Decimal Places On 0n On On All Iterations Scale Confidence Regions Tau Max 10 Convergence Criterion 0.001000 SETUP successfully completed. GeoLab-V1.82S, (C) 1985/86/87BitWise Ideas Inc.[103207687] Page 2

Figure D-16. (Sheet 2 of 8)

U.S. ARMY ENGINEER TOPOGRAPHIC LABORATORIES DWORSHAK DAM A = 6378137.000 B = 6356752.314 X0 = 0.000 Y0 = 0.000 Z0 = 0.000FORMEO: NOTE 6: Reordering was done. OBSERVATION APPROX.SIG. MISCLOSURE OBS TYPE OBS TYPE

3-D X-Coord Diff

3-D Y-Coord Diff

3-D X-Coord Diff 22.8708 25.8258 0.0029 2408.6880 4003 4001 0.0016 -193.5840 1108.0180 4003 4001 -26.6407 22.7040 21.7690 0.0021 7.1790 -74.6270 -50.0120 2401.5070 -118.9530 1158.0230 2108.6340 4001 0.0007 4004 4004 4003 0.0003 4003 0.0006 -25.7900 4004 4003 .1688 4.0528 0.0055 4001 4004 0.0065 0.0062 0.0061 -118.9530
1158.0230
1158.0230
1158.6340
1204.4260
2108.6370
-193.01380
138.01380
138.01380
138.01380
138.01380
138.01380
1204.4190
2108.81330
1210.228.33300
12160.2160
2348.833300
12160.21650
2348.8140
-28.1650
-28.1650
-240.7570
-1237.5120
-1287.3050
-240.75770
-1287.3050
-2359.1440
1184.9690
2348.83370
1213.1310
300.0520 4004 4001 -0.8437 4001 4004 -1.6862 36.75484002 0.0061 0.0079 0.0067 0.0055 0.0072 4001 4002 4002 4003 -27.6797 22.8718 4001 4001 4001 25.8198 4003 4001 -26.6337 -0.9472 4003 4001 0.0047 4005 4001 5.9208 4005 4001 -7.2267 1.1270 0.0073 4005 4001 4005 4004 -1.8630 6.3760 0.0015 4005 4004 0.0006 4005 4004 -1.6762 36.7618 -27.6817 0.0045 4002 4001 3-D X-Coord Diff
3-D X-Coord Diff
3-D X-Coord Diff
3-D X-Coord Diff
3-D X-Coord Diff
3-D X-Coord Diff
3-D X-Coord Diff
3-D X-Coord Diff
3-D X-Coord Diff
3-D X-Coord Diff
3-D X-Coord Diff
3-D X-Coord Diff
3-D X-Coord Diff
3-D X-Coord Diff
3-D X-Coord Diff
3-D X-Coord Diff
3-D X-Coord Diff
3-D X-Coord Diff
3-D X-Coord Diff
3-D X-Coord Diff
3-D X-Coord Diff
3-D X-Coord Diff
3-D X-Coord Diff
3-D X-Coord Diff 0.0104 4002 4001 0.0063 4002 4001 32.4128 24.3928 -23.8437 -33.3760 4001 4006 0.0019 4006 4001 0.0021 4006 4001 4005 4006 0.0004 -18.47604005 4006 0.0007 0.0031 0.0020 16.6190 34.1020 4005 4006 4002 4006 -12.36404006 4002 3.8370 0.7310 -30.8430 20.4520 -0.9532 0.0019 4002 4006 0.0027 0.0040 0.0031 4005 4005 4002 4002 4002 4005 0.0055 4005 4001 5.9218 -7.2327 0.0067 4001 4005 0.0063 4005 4001 3-D X-Coord Diff 3-D Y-Coord Diff 3-D Z-Coord Diff 32.4198 4001 4006 24.3968 0.0066 4006 4001 -23.8487 24.5590 1213.1310 0.0062 4001 4006 3-D X-Coord Diff 4002 4003 -10.93600.0043 3-D Y-Coord Diff -1398.0030 4003 4002 GeoLab-V1.82S, (C) 1985/86/87BitWise Ideas Inc.[103207687] Page 3

Figure D-16. (Sheet 3 of 8)

	378137	.000	B=	6356	5752.3	ORSHAK 314 X0=	= 0.	000	=0Y	0	.000	ZO:	= 	0.00
FORME	Q:													
TΑ	TO	OBS	TYP	E		OBSERV	ATIO	N_	APPR	ox.	SIG.	MI	SCL	OSUR
40006 40006 400011 400011 400011 400011 400011 400011 40001	4003 4003 4003 4002 4002 4002 4002 4002	33333333333333333333333333333333333333	X-Cc Y-Cc X-Cc X-Cc X-Cc X-Cc X-Cc	oord cord cord cord cord cord cord	DDIETER ET ET ET ET ET ET ET ET ET ET ET ET ET	-165 -165 2108 1204 2160 2108 2160 2108	3.878 3.250 3.250 3.417 3.416 3.416 3.426 3.426 3.426 3.426 3.426	00000000000		0000000	0024 00015 00045 00045 00045 0006 0006 0006 0006		-9 -2 -1 367	.0436 .5432 .7977 .76776 .7684 .7678 .76777 .6768 .7678 .7678 .7678 .7688
3eoLa	b-V1.8	25, ((ت) 19	85/8	6/8/B	ıtwise	rdeg	S I	ոշ․լ	T 0 2	20/6	00/]	rd	ge
		 U.S.	ARM	Y EN		R TOPO		īc	LABO	 RAT	ORII	 ES		
 A= 6	 5378137				DW	IORSHAK	DAM						 =	0.00
	378137				DW	IORSHAK	DAM						 = 	0.00
SOLVE	378137	.000	B=	635	DW 6752.	ORSHAK 314 X0	DAM						 = 	0.00
SOLVE	378137 3:	.000 ssfu	B= 	635 comp	6752. 1eted	ORSHAK 314 XO:	DAM = 0.	000	Y0=		.000			
SOLVE	378137 3: E succe	.000 ssfu	B= 	635 comp	6752. 1eted	ORSHAK 314 XO:	DAM = 0.	000	Y0=		.000			
SOLVE	378137 3: E succe ab-V1.8	.000 ssfu	B= 11y (635 comp 85/8	leted 6/87B	itWise	Idea	000 s I	Y0=	103	2076	zo 587]		
SOLVE	378137 3: E succe ab-V1.8	.000 ssfu 2S,(B= lly c)19	635 comp 85/8	leted 6/87B	itWise	Idea	ooo s I	Y0=	103	2076	20 587]	Pa	 ge
SOLVE SOLVE GeoLa	378137 3: E succe ab-V1.8	.000 ssfu 2S,(B= lly c)19	635 comp 85/8	leted 6/87B	itWise	Idea	ooo s I	Y0=	103	2076	20 587]	Pa	 ge

Figure D-16. (Sheet 4 of 8)

U.S. AF	RMY ENGINEER TOPOGRAPH	HIC LABORATOR	RIES
A= 6378137.000 B=	DWORSHAK DAM = 6356752.314 X0= 0.	000 YO= 0.0	000 ZO= 0.000
SOLVE:			
•	<pre>Iteration Count = 2):</pre>		
	INITIAL		ADJUSTED
14 4001 LATITUD 14 2006 LONGITU 14 2006 HEIGHT	DE 46 30 5.78733 UDE -116 19 17.36405 312.18200	FIXED FIXED FIXED	
24 4003 LATITUD 24 4003 LONGITU 24 4003 HEIGHT	DE 46 30 51.48677 UDE -116 17 42.07099 500.68216	0.00000 46 0.00000 -11 0.00001	30 51.48677 16 17 42.07099 500.68217
24 4004 LATITUD 24 4004 LONGITU 24 4004 HEIGHT	DE 46 30 54.09853 UDE -116 17 43.92366 493.11850	0.00000 46 -0.00000 -11	5 30 54.09853 16 17 43.92366 493.11851
24 4002 LATITUE 24 4002 LONGITU 24 4002 HEIGHT	DE 46 30 41.25876 UDE -116 18 23.74916 493.34210	0.00000 46 -0.00001 -11 0.00003	5 31 41.25876 16 18 23.74917 493.34213
24 4005 LATITUE 24 4005 LONGITU 24 4005 HEIGHT	DE 46 30 55.00394 UDE -116 17 46.44097 503.72111	-0.00000 46 -0.00000 -11	30 36.93927 16 17 46.44097 503.72111
24 4006 LATITUD 24 4006 LONGITU 24 4006 HEIGHT	DE 46 30 56.68676 UDE -116 17 48.02294 493.25364	0.00000 46 0.00001 -11 0.00003	30 56.68676 L6 17 48.02294 493.25367
GeoLab-V1.82S, (C) 1	1985/86/87BitWise Idea	as Inc.[10320	07687] Page 7
U.S. AF	RMY ENGINEER TOPOGRAPH	HIC LABORATOR	RIES
A= 6378137.000 B=	DWORSHAK DAM = 6356752.314 X0= 0.	.000 YO= 0.0	000 ZO= 0.000
Adjusted Cartesian	n Coordinates:		
CODE IDENT.	X-COORDINATE Y-COO	ORDINATE	Z-COORDINATE
24 40031 24 40041 24 40021 24 40051 24 40061	1948002.5548 -39423 1948009.7358 -39423 1948302.6080 -39403 1948052.0934 -39423 1948062.4335 -39423	346.3361 271.7102 948.3316 236.2903 L81.0887	4605137.8787 4605187.8935 4606190.1331 4605213.8271 4605242.9935
SOLVE successfully	y completed.		
GeoLab-V1.82S,(C)1	1985/86/87BitWise Idea	as Inc.[10320)7687] Page 8
	RMY ENGINEER TOPOGRAPH DWORSHAK DAM = 6356752.314 X0= 0		
INVERT:			
INVERT successfull	ly completed.		
GeoLab-V1.82S,(C)1	1985/86/87BitWise Idea	as Inc. [10320)7687 Page 9

Figure D-16. (Sheet 5 of 8)

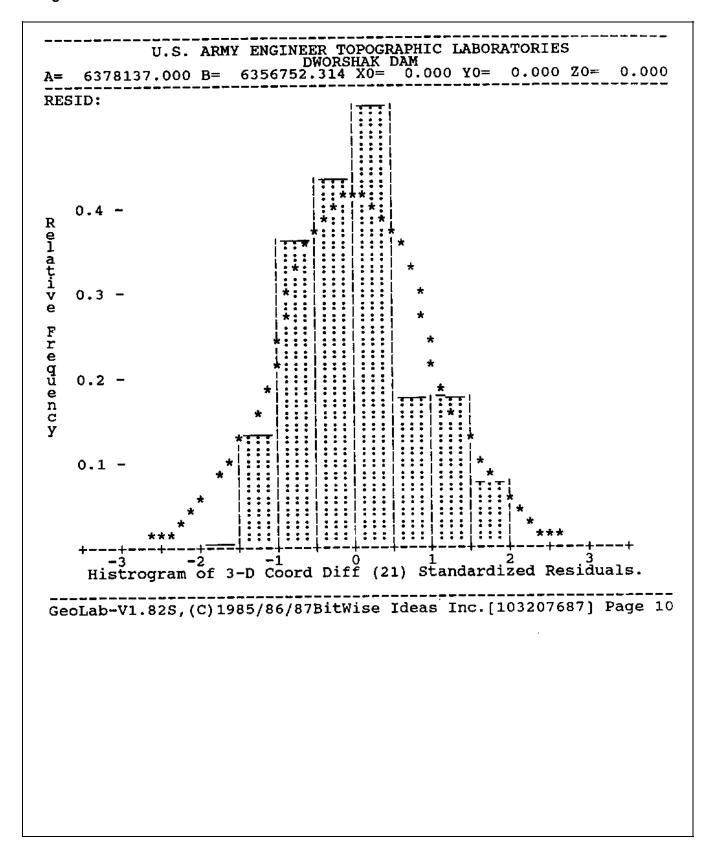


Figure D-16. (Sheet 6 of 8)

U.S. ARMY ENGINEER TOPOGRAPHIC LABORATORIES

DWORSHAK DAM

A= 6378137.000 B= 6356752.314 X0= 0.000 Y0= 0.000 Z0= 0.000 RESID: STATISTICS SUMMARY Residual Critical Value Type
Residual Critical Value
Convergence Criterion
Final Iteration Counter Value
Confidence Level Used
Number of Flagged Residuals
Estimated Variance Factor
Number of Degrees of Freedom Tau Max 3.3469 0.001000 95,0000 0.8676 Chi-Square Test on the Variance Factor: 5.9685e-001 < 1.0000 < 1.3763e+000 ? THE TEST PASSES. RESID successfully completed. GeoLab-V1.82S, (C) 1985/86/87BitWise Ideas Inc. [103207687] Page 11 U.S. ARMY ENGINEER TOPOGRAPHIC LABORATORIES

DWORSHAK DAM

A= 6378137.000 B= 6356752.314 X0= 0.000 Y0= 0.000 Z0= 0.000 ELLIPSE: NOTE: All confidence regions were computed using the following factors: Variance factor used 0.86755 Estimated variance factor = 0.86755 1-D expansion factor 1.960 2-D expansion factor 2.448 = 3-D expansion factor 2.795 Note that, for relative confidence regions, precisions are computed from the ration of the major semi-axis and the spatial distance between the two stations. Error ellipses for which all covariance matrix elements were not computed by INVERT, are marked with an asterick(*) GeoLab-V1.82S, (C) 1985/86/87BitWise Ideas Inc. [103207687] Page 12

Figure D-16. (Sheet 7 of 8)

```
U.S. ARMY ENGINEER TOPOGRAPHIC LABORATORIES
                                DWORSHAK DAM
A= 6378137.000 B= 6356752.314 X0= 0.000 Y0= 0.000 Z0= 0.000
ELLIPSE:
2-D AND 1-D STATION CONFIDENCE REGIONS ( 95.000 %):
            MAJOR SEMI-AXIS MINOR SEMI-AXIS
                                                                    VERTICAL
                                                      AZ(MAJ)
                        0.0034
                                                         76.62
                                                                      0.0056
                                             0.0022
4003
                                                                      0.0057
                                             0.0023
                                                         82.71
                        0.0036
4004
                                            0.0026
                                                        89.02
                                                                      0.0061
4002
                        0.0035
                                                         82.89
                                                                      0.0057
                                             0.0023
4005
                        0.0035
                                                                      0.0056
                                                         79.03
                        0.0035
                                             0.0022
4006
GeoLab-V1.82S, (C) 1985/86/87BitWise Ideas Inc.[103207687] Page 13
             U.S. ARMY ENGINEER TOPOGRAPHIC LABORATORIES
                                DWORSHAK DAM
A = 6378137.000 B = 6356752.314 X0 = 0.000 Y0 = 0.000 Z0 = 0.000
ELLIPSE:
2-D and 1-D RELATIVE STATION CONFIDENCE REGIONS ( 95.000 %):
FROM TO
              MAJ.SEMI MIN.SEMI AZ(MAJ) VERT.
                                                      SPAT.DIST. PREC.
                                                      90.1225 25.220PPM
1775.2993 1.847PPM
143.1265 17.408PPM
204.7957 8.998PPM
1685.7014 2.064PPM
                                       89.79 0.0033
4003
       4004
                 0.0023
                            0.0008
                                     96.46 0.0057
104.89 0.0038
                            0.0026
                 0.0033
4003
       4002
                 0.0025
4003
       4005
                            0.0016
                                     130.30 0.0027
97.42 0.0059
                            0.0014
                 0.0018
       4006
4003
       4002
                 0.0035
4004
                                     128.56 0.0027 61.4342
102.27 0.0039 118.4286
92.33 0.0056 1634.8752
85.85 0.0056 1573.0376
                            0.0014
                                                                   30.745PPM
                 0.0019
       4005
4004
                                                                  21.633PPM
2.019PPM
2.098PPM
                            0.0016
                 0.0026
4004
       4006
                 0.0033
                            0.0025
4002
       4005
                            0.0024
4002
       4006
                                       88.94 0.0033
                                                         62.8290 36.322PPM
       4006
                 0.0023
                            0.0009
4005
ELLIPSE successfully completed.
GeoLab-V1.82S, (C) 1985/86/87BitWise Ideas Inc. [103207687] Page 14
```

Figure D-16. (Sheet 8 of 8)

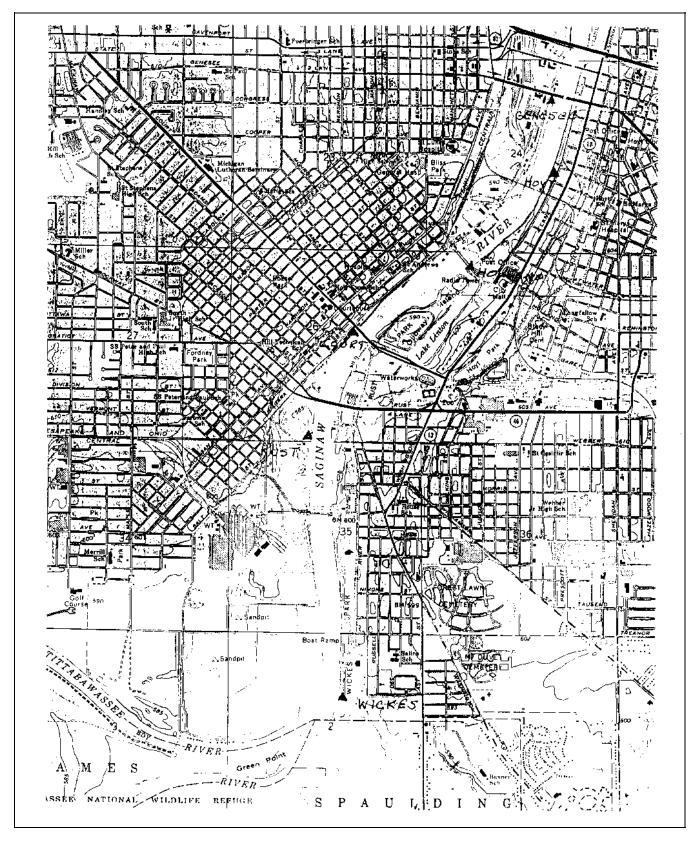


Figure D-17. Project area and control points, Upper Saginaw River project (Continued)

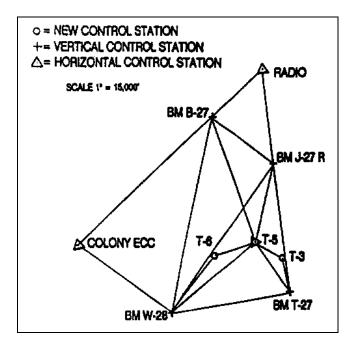


Figure D-17. (Concluded)

support digital mapping of the Upper Saginaw River. Saginaw's function was to provide horizontal control in this area for mapping purposes. Six points (3 pairs) were established, see Figure D-17. Control was brought in from two First-Order NGS horizontal control stations, stations Jonas and Parrish.

- c. Four Ashtech Dual Frequency (L1/L2) GPS receivers and antennas with ground planes were used for this project.
- d. Prior to any data collection, a preplanning survey was conducted to determine any obstructions (see Figure D-18) and examine existing control. Control station Jonas and Parrish had some sinking problems due to thawing ground. Station Jonas was readjusted during the survey but station Parrish was not.
- e. A satellite visibility chart was run to determine occupation times for each session on both day 083 and day 084. The chart included the number of satellites and PDOP for the project area. The charts were run with an elevation mask of 20 deg (see Figure D-19) and 25 deg (see Figure D-20).
- f. There were three survey sessions held on day 083 and one on day 084. Table D-5 lists sessions, occupation

times, and stations occupied for day 083 and Table D-6 lists day 084 occupation times and stations.

D-11. Actual Survey

The survey was performed as planned, with three sessions on day 083 and one session on day 084. An observation log (see Figure D-21) for each station was recorded by the observer. This information was used during post-processing.

D-12. Data Processing and Adjustment

- a. The GPS baselines were processed using Ashtech baseline reduction software (GPPS). All four sessions were processed. An output file from this program is shown in Figure D-22. From these results, session 083 A and B and 084 seemed to be satisfactory. Session 083 C tagged all the float solutions except for the vector between 4008 and 4009. The plots for these vectors, between 4008 and 4009, appeared to have been affected by the ionosphere.
- b. After baseline processing was completed, a loop closure was performed to show closures with known control (see Figure D-23) and one was performed to show closures with the unknown control stations.
- c. Once the closures were completed, a free adjustment and a constrained adjustment were performed on all processed baselines for Julian days 083 and 084. Figure D-24 was the input file used for the free adjustment. The constrained adjustment held fixed station PARRISH's X,Y,Z and station JONAS' X,Y. The results of the constrained adjustment are listed in Figure D-25.
- d. After the final adjustment of the data, CORPSCON was used to convert the station latitude and longitude to state plane coordinates. This file is listed in Figure D-26.

D-13. Station Descriptions

Station descriptions with adjusted coordinates for each control station set were formulated. These are listed in Figure D-27.

" G.P.S. PREPLANNING SURVEY "
PROJECT: UPPER SAGINAW
STATION NAME: HOYT RIGHT OF ENTRY YES DATE:
BORIZONTAL CONTROL: KNOWN UNKNOWN (IF UNKNOWN GIVE APPROX. LAT/LONG)
IF KNOWN GIVE VALUES: DATUM PROJECTION ZONE
LATITUDENORTH
LONGITUDEEAST
VERTICAL CONTROL: KNOWN UNKNOWN (IF UNKNOWN GIVE APPROX. ELEV.)
IF KNOWN GIVE VALUES: DATUM ELEV. FT METERS
OBSEVATION SITE: COMPLETE OBSTRUCTION POLAR MAP (SEE BELOW)
ACCESSABILITY: CAR/TRUCK HIKE BOAT
DISTANCE VEHICLE CAN BE PARKED TO STATION:
PRIVATE PROPERTY PUBLIC PROPERTY KEY FOR GATE REQUIRED
NOTIFICATION OF PROPERTY OWNER REQUIRED PRIOR TO ACCESS NO.
NAME: SAG. RIVER WALK IF YES PHONE #
OBSTRUCTION POLAR MAP:
INDICATE OBSTRUCTIONS: EX. TREES, BUILDINGS, (SEE EXAMPLE ON BACK)
REMARKS:
e y
W-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1
71111111 // ///// 30.
\$\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
2/0 150
s PIP
20-

Figure D-18. Preplanning survey, Upper Saginaw River project

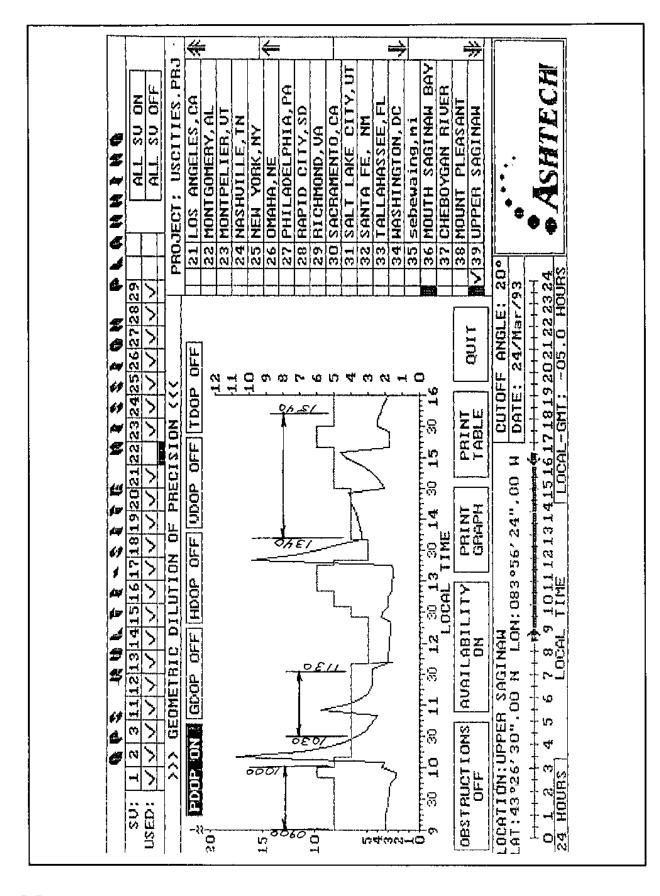


Figure D-19. Satellite visibility chart, elevation mask 20 deg

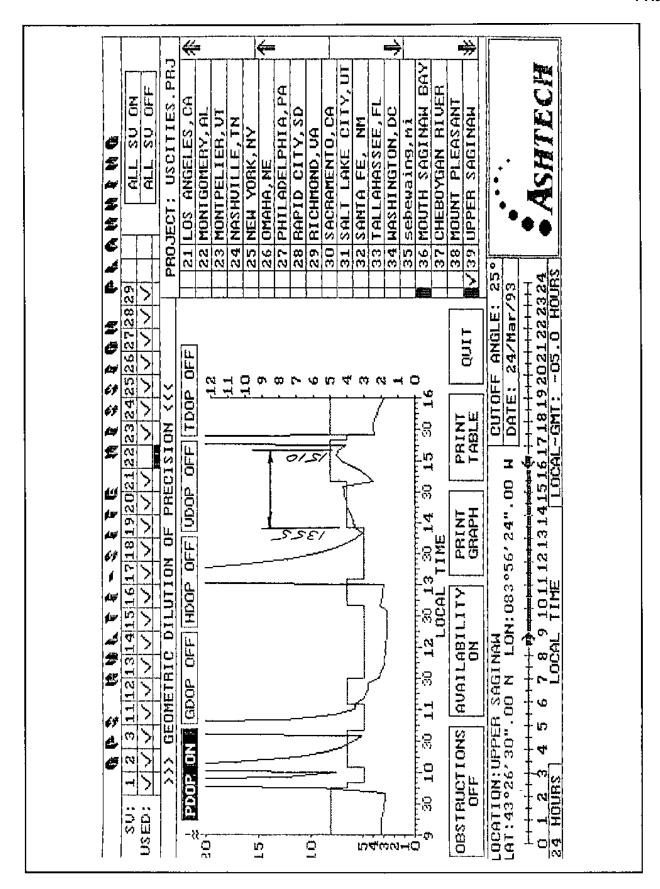


Figure D-20. Satellite visibility chart, elevation mask 25 deg

EM 1110-1-1003 1 Aug 96

Table D-5 Day 083		
Session A	Session B	Session C
0900-1000	1030-1130	1340-1540
HOYT	WICKES	WICKES
GENESSEE	RUST	RUST
HOLLAND	HOLLAND	JONAS
EWALD	EWALD	PARRISH

able D-6 ay 084	
session A 335-1535	
IOYT BENESEE ONAS ARRISH	

DATE 3-74-93 JULIAN DATE 3	

SESSION "A" STATION NAME: HOYT STATION # 4004 SKED.START 0900 ACTUAL START 0850 SKED.STOP 1000 ACTUAL STOP ANTENNA HEIGHT: INCHES: BEFORE 5944 AFTER 5944 MEAN 59 METERS: BEFORE 1.505 AFTER 1.505 MEAN 1.5 ***********************************	*****
SKED.START 0900 ACTUAL START 0850 SKED.STOP 1000 ACTUAL STOP ANTENNA HEIGHT: INCHES: BEFORE 5944 AFTER 5944 MEAN 59 METERS: BEFORE 1.505 AFTER 1.505 MEAN 1.5	
ANTENNA HEIGHT: INCHES: BEFORE <u>594</u> AFTER <u>594</u> MEAN <u>59</u> METERS: BEFORE <u>1.505</u> AFTER <u>1.505</u> MEAN <u>1.5</u> ***********************************	
METERS: BEFORE 1.505 AFTER 1.505 MEAN 1.5	

	505 <u>/</u>
SESSION "B"	*****
STATION NAME: WICKES STATION # 4008	
SKED. START 1030 ACTUAL START 1030 SKED. STOP 11:30 ACTUAL STOP	
ANTENNA HEIGHT: INCHES: BEFORE 6236 AFTER 6236 MEAN 62	
METERS: BEFORE 1.579 AFTER 1.579 MEAN 1.5	5792
**************************************	******
STATION NAME: WICKES STATION # 4008	
SKED. START 1340 ACTUAL START 1335 SKED. STOP 1540 ACTUAL STOP	<u>1540</u>
ANTENNA HEIGHT: INCHES: BEFORE 643" AFTER 648" MEAN 6	428"
METERS: BEFORE 1.636 MEAN 1.	<u> 1361/</u>
**************************************	<*******
STATION NAME: STATION #	
SKED.START ACTUAL START SKED.STOP ACTUAL STOP_	
ANTENNA HEIGHT: INCHES: BEFORE AFTER MEAN	
METERS: BEFORE AFTER MEAN	
**************************************	*****
S/N 501 ANTENNA # 001 ANT. CABLE LENGTH 50' POWER SUPPLY	24V
GROUND PLANES USED <u>YES</u> L1 <u>YES</u> L2 <u>YES</u> ************************************	
SESSION "A" REC. JU #3 01-12-15-20-21-23-25 (LOST #23-091)	o 5 ?o}
1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -	· · •
SESSION "A" REC. JU "3 01-12-15-20-21-23-25 (LOST *23-091) SESSION "B" " # 01-14-15-20-25-29 (LOST *15-1045 " "20-1120) SESSION "C" " # 03-14-18-19-25-28-29 (LOST *14-1350	_

Figure D-21. Observation log, Upper Saginaw River project

```
Version: 4.5.00
                              Program: LINECOMP
Ashtech, Inc. GPPS-L
                           Fri Mar 26 10:34:33 1993
Project information
                         |25-character project name | The | is in column 26
GPS Survey
. ]
                         |5-character session name
0843A
Project information
Known-station parameters
                          Receiver identifier used in "LOGTIMES" file
00
                          Project station number
000000
                           4-character short name
1001
FIXED STATION
                           25-character long name
                           25-character comment field
503 003 005
                          Position extraction (0=below,1=U-file,2=proj. file
N 43 33 32.67131
                          Latitude deq-min-sec (q=good;b=bad)
                           E-Longitude deg-min-sec (g=good;b=bad)
E 276 11 32.13854
                           W-Longitude deg-min-sec (g=good; b=bad)
W 83 48 27.86146
                           Ellipsoidal height (m) (g=good;b=bad)
   150.7356
                          North antenna offset(m)
     0.0000
                           East antenna offset (m)
     0.0000
                           Vert antenna offset (m): slant/radius/added offset
  1.6990 0.1150 0.0000
                           Temperature (degrees C)
    20.0
    50.0
                           Humidity (percent)
                           Pressure (millibars)
  1010.0
                          Measurement filename (restricted to 24 characters)
U1001A93.084
Known-station parameters
Unknown-station parameters
                           Receiver identifier used in "LOGTIMES" file
00
                           Project station number
000000
                           4-character short name
4005
                           25-character long name
UNKNOWN STATION
                           25-character comment field
504 004 007
                           Position extraction (0=below,1=U-file,2=proj. file
0
                           Latitude deg-min-sec (g=good;b=bad)
N 43 26 1.65174
                           E-Longitude deg-min-sec (g=good;b=bad)
E 276 3 25.93899
                           W-Longitude deg-min-sec (g=good;b=bad)
W 83 56 34.06101
                           Ellipsoidal height (m) (g=good; b=bad)
   149.5289
                           North antenna offset(m)
     0.0000
     0.0000
                           East antenna offset (m)
                           Vert antenna offset (m): slant/radius/added_offset
  1.6350 0.1150 0.0000
                           Temperature (degrees C)
    20.0
                           Humidity (percent)
    50.0
                           Pressure (millibars)
  1010.0
                           Measurement filename (restricted to 24 characters)
U4005A93.084
Unknown-station parameters
```

Figure D-22. Output file, Upper Saginaw River project (Ashtech) (Sheet 1 of 5)

```
Run-time parameters
                          First epoch to process
    1
                          Final epoch to process (-1 = last available)
   -1
20.0
                          Elevation cutoff angle (degrees)
                          Data to process (0=Wdln;1=L1;2=L2;3=L1c;6=RpdSt)
0.010000
                          Convergence criterion (meters)
00 00 00 00 00 00
                          Omit these satellites (up to 7)
                          Maximum iterations for tlsq and dlsq
00 00 00 00 00 00
                          Forbidden reference SVs (up to 7)
                          Apply tropo delay correction
yes
Run-time parameters
LINECOMP 4.5.00 12/11/92
FIXED U-File from L1 only receiver.
UNKWN U-File from L1 only receiver.
FIXED U-File used BROADCAST orbits.
UNKWN U-File used BROADCAST orbits.
Common start of two UFILES: 1993/03/25 18:35:60.00
           of two UFILES: 1993/03/25 20:32:60.00
Common end
    Selected first epoch: 1
    Selected last epoch: 352
                      221 triple-difference measurements.
For SV 11 there are
For SV 18 there are
                      351 triple-difference measurements.
For SV 19 there are
                      351 triple-difference measurements.
For SV 27 there are
                      73 triple-difference measurements.
For SV 28 there are
                      348 triple-difference measurements.
For SV 29 there are
                      338 triple-difference measurements.
Epoch interval (seconds): 20.000000
THE TRIPLE DIFFERENCE SOLUTION (L1)
Measure of geometry: 0.640415
                       num used = 1323
num meas = 1329
                                                rms resid = 0.002595(m)
Post-Fit Chisq = 3459.383
                                    NDF
                                              = 1\overline{2}.250
  Sigmax (m):
                   0.870234
  Sigmay (m):
Sigmaz (m):
                   0.572256
                   0.270963
  х
        Y
              7.
x 1.00
y 0.71y 1.00
z-0.40z-0.59z 1.00
del station: 0.005074 0.001394 -0.000650
                                          Station2: UNKNOWN STATION
     Station1: FIXED STATION
                (00000)
                                                     (00000)
                          (1001)
                                                                 (4005)
```

Figure D-22. (Sheet 2 of 5)

```
Latitude: 43.55907536 43 33 32.67131
                                                 43.43379221 43 26 1.65195
 E-Long : 276.19226071 276 11 32.13854
                                                276.05720501 276 3 25.93803
 W-Long : 83.80773929 83 48 27.86146
                                                 83.94279499 83 56 34.06197
 E-Height: 150.7356
                                                 149.5416
 Baseline vector:
                      -9839.2603
                                    -10690.9170
                                                   -10098.3296
 Markl xyz :
                499359.2995 -4602470.6194
                                             4372824.2683
 Az1 Ell D1:
                   218.17046
                                   -0.0834
                                               17694.1519
 E1 N1 U1
                -10912.4583
            :
                               -13919.7439
                                                  -1.1940
 Mark2 xyz :
                489520.0392 -4613161.5364
                                             4362725.9387
 Az2 E12 D2 :
                    38.07750
                                   -0.0757
                                               17694.1519
 E2 N2 U2
          :
                 10935.0401
                                13919.4351
                                                   1.1940
Double-Difference Epochs:
  Prn:
        11 Start epoch:
                          132
                               End epoch:
                                           352
           Start epoch:
                          2
2
  Prn:
        18
                               End epoch:
                                           352
  Prn:
           Start epoch:
        19
                               End epoch:
                                           352
        27 Start epoch:
                          280
  Prn:
                               End epoch:
                                           352
        28 Start epoch:
                          5
  Prn:
                               End epoch:
                                           352
  Prn:
        29 Start epoch:
                            2
                               End epoch: 339
THE FLOAT DOUBLE DIFFERENCE SOLUTION (L1)
Measure of geometry: 0.103203
                                  Wavelength = 0.190294 (m/cycle)
num meas = 1332
                        num used = 1317
                                                 rms resid = 0.004061(m)
Post-Fit Chisq =
                    42.171
                                     NDF
                                                   12.194
Reference SV: 18
  SV
         Ambiguity
                         FIT
                                Meas
                                          SV
                                                 Ambiquity
                                                                 FIT
                                                                        Meas
  11
          22406589.878f
                         0.024
                                 211
                                          19
                                                  21161231.999f
                                                                 0.018
                                                                         350
  27
                        0.024
                                  72
          10785453.076f
                                          28
                                                  28836460.832f
                                                                 0.022
                                                                         348
  29
           5129536.945f 0.021
                                 336
  Sigmax (m):
                   0.015558
  Sigmay (m):
                   0.010159
  Sigmaz (m):
                   0.004803
  SigmaN (cy):
                   0.075992
  SigmaN (cy):
                   0.018403
  SigmaN (cy):
                   0.034642
  SigmaN (cy):
                   0.089934
  Sigman (cy):
                   0.033807
  X
        У
                    N
                          N
                                N
                                      N
                                            N
x 1.00
y 0.72y 1.00
z-0.50z-0.65z 1.00
N 0.97N 0.72N-0.59N 1.00
N-0.10N 0.42N-0.05N-0.05N 1.00
```

Figure D-22. (Sheet 3 of 5)

```
N-0.31N 0.26N-0.05N-0.26N 0.67N 1.00
N 0.99N 0.76N-0.52N 0.98N-0.00N-0.24N 1.00
N 0.89N 0.57N-0.60N 0.93N-0.11N-0.32N 0.90N 1.00
del station: 0.000000 0.000000 0.000000
                                       Station2: UNKNOWN STATION
    Station1: FIXED STATION
                                                           (4005)
                                                 (00000)
               (00000)
                         (1001)
                                             43.43379217 43 26 1.65179
Latitude: 43.55907536 43 33 32.67131
                                            276.05720515 276 3 25.93854
 E-Long : 276.19226071 276 11 32.13854
                                             83.94279485 83 56 34.06146
 W-Long : 83.80773929 83 48 27.86146
                                             149.5272
 E-Height: 150.7356
                   -9839.2497 -10690.9086
                                               -10098.3429
 Baseline vector:
                                          4372824.2683
               499359.2995 -4602470.6194
Markl xyz :
                                           17694.1485
                                -0.0834
 Az1 E\overline{1}1 D1 :
                  218.17042
                                              -1.2084
                            -13919.7486
 E1 N1 U1 :
               -10912.4468
                                        4362725.9254
 Mark2 xyz : 489520.0498 -4613161.5280
                                -0.0756
                   38.07746
                                           17694.1485
 Az2 E12 D2 :
                              13919.4398
                                               1.2084
 E2 N2 U2 :
              10935.0287
AMBIGUITY RESOLUTION
                                2
                                          3
                     1
                                        0.000
                    0.008
                              0.000
                                                  0.000
Abs Contrast
                            100.000
                                      100.000
                                                100.000
Contrast
                                     4624.842
                                               5296.077
                           4588.301
Change Chi2
                  38.426
                                     22406589
                                               22406590
Bias S18:11
                           22406591
                 22406590
                                     21161232
                                               21161232
                           21161232
Bias S18:19
                 21161232
                                     10785453
                                               10785454
                           10785453
Bias S18:27
                 10785453
                                    28836460
                                               28836461
Bias S18:28
                 28836461
                           28836462
                                     5129537
                            5129537
                                               5129537
Bias S18:29
                  5129537
NDF=136.7000 Chi2=42.1709
THE FIXED DOUBLE DIFFERENCE SOLUTION (L1)
Measure of geometry: 0.030142 Wavelength = 0.190294 (m/cycle)
                   num meas = 1332
                                               1\overline{2}.176
                                  NDF
Pos\overline{t}-Fit Chisq = 77.434
                                 Integer Search Ratio = 100.000
Reference SV: 18
                                                           FIT
                                                                   Meas
                                      SV Ambiguity
                       FIT
                              Meas
  sv
        Ambiguity
                                       19
                                              21161232.000X 0.029
                                                                    350
         22406590.000X 0.031 213
  11
                                       28
                                              28836461.000X 0.025
                                                                    349
         10785453.000X 0.053
                               65
  27
                               338
  29
          5129537.000X 0.024
  Sigmax (m): 0.002257
```

Figure D-22. (Sheet 4 of 5)

Sigmay (m): 0.005658 Sigmaz (m): 0.004546 X Y x 1.00 y 0.19y 1.00 z 0.12z-0.72z 1.00 del station: 0.000016 0.000949 -0.000715 Station2: UNKNOWN STATION Station1: FIXED STATION (4005)(00000) (00000) (1001) Latitude: 43.55907536 43 33 32.67131 43.43379220 43 26 1.65191 276.05720552 276 3 25.93986 E-Long : 276.19226071 276 11 32.13854 83.94279448 83 56 34.06014 W-Long : 83.80773929 83 48 27.86146 149.5220 E-Height: 150.7356 Baseline vector: -9839.2208 -10690.8991 -10098.3438499359.2995 -4602470.6194 4372824.2683 Mark1 xyz : 17694.1272 Az1 \overline{El} 1 D1 : -0.0835 218.17035 E1 N1 U1 : Mark2_xyz : -13919.7449 -1.2136 -10912.4172 489520.0787 -4613161.5185 4362725.9246 Az2 E12 D2 : 17694.1272 38.07739 -0.0756 1.2136 E2 N2 U2 : 10934.9990 13919.4360 Fri Mar 26 10:39:26 1993

Figure D-22. (Sheet 5 of 5)

START:	ING STATION N	NAME: 1001					
LINE	FROM	TO		DX	DY	DZ .	LENGTH
1	1001	4008	0833C	-11172.423	-14312.145	-13760.192	22781.64
17	4008	4009	0833B	-412.530	1492.440	1614.982	2237.34
14	4007	4009	0833B	-313.662	-602.201	-613.237	914.92
11	4006	4007	0833A		-467.386	-388.225	1056.75
9	4006	4004	0833A	628.445			1047.09
24	4005	4004	0843A	60.920			654.41
20	1001	4005	0843A			-10098.344	
	STATION		ITUDE	LONGIT	UDE E	LEV. G	Н
	1001	43	33 32.67		8 27.85821	150.615	0.000
	4008		23 18.39		7 49,93702	146.842	0.000
	4009		24 30.42		8 1.19491		0.000
	4007		24 57.46		7 44.51670	156.913	0.000
	4006		25 14.92		7 4.10971	152.264	0.000
	4004		25 40.45		6 33.44979	148.694	0.000
	4005		26 1.65		6 34.05326		0.000
	1001		33 32.67		8 27.85454		0.000
(ISC) S:	ERSE LENGTH = LOSURES (LAT. ince geoid he omputed eleve	, LON., El	LEV., meto not give	ers): -0.6 n, the	LOOP MISC		.0 ppm
MISC S: CC	LOSURES (LAT. ince geoid he omputed eleva	., LON., Eights are ations may	LEV., meto not give	ers): -0.6 n, the	LOOP MISC		.0 ppm
MISCI S: CC	LOSURES (LAT. ince geoid he omputed eleve ING STATION N	., LON., Ending the street of	LEV., meto not give	ers): -0.4 n, the usly in erro	LOOP MISC	LOSURE = 4	
MISC S: CC TART: LINE	LOSURES (LAT. ince geoid he omputed eleve ING STATION N FROM	i, LON., Ending the Atlanta may NAME: 1002 TO	not given be seriou	ers): -0.4 n, the usly in erro	LOOP MISC	LOSURE = 4 DZ	LENGTH
MISCI S: C: TART: LINE 23	LOSURES (LAT. ince geoid he omputed eleve ING STATION N FROM 1002	i, LON., Ending the Atlanta may NAME: 1002 TO 4005	not give be serior	ers): -0.4 n, the usly in erro DX 7853.486	LOOP MISC: DY -20463.167	DZ -22275.296	LENGTF 31250.71
S: CC TART: LINE 23 10	LOSURES (LAT. ince geoid he omputed eleva ING STATION N FROM 1002 4006	ights are ations may NAME: 1002 TO 4005 4005	not give be serior 0843A 0833A	ers): -0.4 n, the usly in erro DX 7853.486 567.529	DY -20463.167	DZ -22275.296 1045.274	LENGTF 31250.71 1592.75
S: CC TART: LINE 23 10 12	LOSURES (LAT. ince geoid he omputed eleva ING STATION N FROM 1002 4006 4006	LON., Ending the Actions may NAME: 1002 TO 4005 4005 4007	not give be serior 0843A 0833A 0833B	DX 7853.486 567.529 -864.618	DY -20463.167 1059.329 -467.386	DZ -22275.296 1045.274 -388.229	LENGTF 31250.71 1592.75 1056.75
S: CC TART: LINE 23 10 12	LOSURES (LAT. ince geoid he omputed eleva ING STATION N FROM 1002 4006 4006 4008	LON., Ending the Actions may NAME: 1002 TO 4005 4005 4007 4007	not give be serior 0843A 0833A 0833B 0833B	DX 7853.486 567.529 -864.618 -98.867	DY -20463.167 1059.329 -467.386 2094.641	DZ -22275.296 1045.274 -388.229 2228.220	LENGTF 31250.71 1592.75 1056.75 3059.78
S: CC FART: LINE 23 10 12 16 18	LOSURES (LAT. ince geoid he omputed eleva ING STATION N FROM 1002 4006 4006 4008 4009	A, LON., Eleights are ations may NAME: 1002 TO 4005 4005 4007 4007 4008	0843A 0833A 0833B 0833C	DX 7853.486 567.529 -864.618 -98.867 412.552	DY -20463.167 1059.329 -467.386 2094.641 -1492.436	DZ -22275.296 1045.274 -388.229 2228.220 -1614.997	LENGTH 31250.73 1592.75 1056.73 3059.78 2237.36
S: CC TART: LINE 23 10 12 16 18 13	LOSURES (LAT. ince geoid he omputed eleva ING STATION N FROM 1002 4006 4006 4008 4009 4006	A, LON., Eleights are ations may NAME: 1002 TO 4005 4005 4007 4007 4008 4009	0843A 0843A 0833A 0833B 0833B 0833C 0833B	DX 7853.486 567.529 -864.618 -98.867 412.552	DY -20463.167 1059.329 -467.386 2094.641 -1492.436 -1069.587	DZ -22275.296 1045.274 -388.229 2228.220 -1614.997 -1001.466	LENGTH 31250.73 1592.75 1056.73 3059.78 2237.36 1880.23
S: CC TART: LINE 23 10 12 16 18 13 9	LOSURES (LAT. ince geoid he omputed eleva ING STATION N FROM 1002 4006 4006 4008 4009 4006 4006	A, LON., Eleights are ations may NAME: 1002 TO 4005 4005 4007 4007 4008 4009 4004	0843A 0843A 0833A 0833B 0833B 0833C 0833B 0833A	DX 7853.486 567.529 -864.618 -98.867 412.552 -1178.280 628.445	DY -20463.167 1059.329 -467.386 2094.641 -1492.436 -1069.587 613.864	DZ -22275.296 1045.274 -388.229 2228.220 -1614.997 -1001.466 569.761	LENGTH 31250.73 1592.75 1056.75 3059.76 2237.36 1880.23
S: CC TART: LINE 23 10 12 16 18 13 9 24	LOSURES (LAT. ince geoid he omputed eleva ING STATION N FROM 1002 4006 4006 4008 4009 4006 4006 4006 4006	A, LON., Eleights are ations may NAME: 1002 TO 4005 4007 4007 4008 4009 4004 4004	0843A 0843A 0833A 0833B 0833B 0833C 0833B 0833A 0833A	DX 7853.486 567.529 -864.618 -98.867 412.552 -1178.280 628.445 60.920	DY -20463.167 1059.329 -467.386 2094.641 -1492.436 -1069.587 613.864 -445.464	DZ -22275.296 1045.274 -388.229 2228.220 -1614.997 -1001.466 569.761 -475.513	LENGTH 31250.71 1592.75 1056.78 3059.78 2237.36 1880.23 1047.09
TART: LINE 23 10 12 16 18 13 9 24 8	LOSURES (LAT. ince geoid he omputed eleva ING STATION N FROM 1002 4006 4006 4008 4009 4006 4006 4006 4006 4006 4005	A, LON., Eleights are ations may NAME: 1002 TO 4005 4007 4007 4008 4009 4004 4004 4007	0843A 0843A 0833A 0833B 0833B 0833C 0833B 0833A 0833A	DX 7853.486 567.529 -864.618 -98.867 412.552 -1178.280 628.445 60.920 -1432.144	DY -20463.167 1059.329 -467.386 2094.641 -1492.436 -1069.587 613.864 -445.464 -1526.716	DZ -22275.296 1045.274 -388.229 2228.220 -1614.997 -1001.466 569.761 -475.513 -1433.499	LENGTH 31250.71 1592.75 1056.75 3059.76 2237.36 1880.23 1047.09 654.41 2537.08
S: CC TART: LINE 23 10 12 16 18 13 9 24	LOSURES (LAT. ince geoid he omputed eleva ING STATION N FROM 1002 4006 4006 4008 4009 4006 4006 4006 4006 4006 4005	A, LON., Eleights are ations may NAME: 1002 TO 4005 4007 4007 4008 4009 4004 4004	0843A 0843A 0833A 0833B 0833B 0833C 0833B 0833A 0833A	DX 7853.486 567.529 -864.618 -98.867 412.552 -1178.280 628.445 60.920 -1432.144 -313.662	DY -20463.167 1059.329 -467.386 2094.641 -1492.436 -1069.587 613.864 -445.464 -1526.716 -602.201	DZ -22275.296 1045.274 -388.229 2228.220 -1614.997 -1001.466 569.761 -475.513	LENGTH 31250.71 1592.75 1056.75 3059.76 2237.36 1880.23 1047.09 654.41 2537.08 914.92
S: CC TART: LINE 23 10 12 16 18 13 9 24 8 14	LOSURES (LAT. ince geoid he omputed eleva ING STATION N FROM 1002 4006 4006 4008 4009 4006 4006 4005 4005 4007 1002 STATION	A, LON., Ending to a serious may NAME: 1002 TO 4005 4007 4007 4008 4009 4004 4004 4007 4009 4009	0843A 0843A 0833A 0833B 0833B 0833B 0833B 0833A 0833A 0833A 0833A	DX 7853.486 567.529 -864.618 -98.867 412.552 -1178.280 628.445 60.920 -1432.144 -313.662 6107.640	DY -20463.167 1059.329 -467.386 2094.641 -1492.436 -1069.587 613.864 -445.464 -1526.716 -602.201 -22591.898	DZ -22275.296 1045.274 -388.229 2228.220 -1614.997 -1001.466 569.761 -475.513 -1433.499 -613.237 -24322.208 LEV. G	LENGTH 31250.71 1592.75 1056.75 3059.76 2237.36 1880.23 1047.09 654.41 2537.08 914.92 33753.70
S: CC TART: LINE 23 10 12 16 18 13 9 24 8 14	LOSURES (LAT. ince geoid he omputed eleva ING STATION N FROM 1002 4006 4006 4008 4009 4006 4006 4005 4005 4007 1002 STATION 1002	LATT	0843A 0843A 0833A 0833B 0833B 0833B 0833B 0833A 0833A 0843A 0833A 0833A 0833A	DX 7853.486 567.529 -864.618 -98.867 412.552 -1178.280 628.445 60.920 -1432.144 -313.662 6107.640 LONGIT	DY -20463.167 1059.329 -467.386 2094.641 -1492.436 -1069.587 613.864 -445.464 -1526.716 -602.201 -22591.898 UDE E	DZ -22275.296 1045.274 -388.229 2228.220 -1614.997 -1001.466 569.761 -475.513 -1433.499 -613.237 -24322.208 LEV. G 162.300	LENGTH 31250.71 1592.75 1056.75 3059.76 2237.36 1880.23 1047.09 654.41 2537.08 914.92 33753.02
S: CC TART: LINE 23 10 12 16 18 13 9 24 8 14	LOSURES (LAT. ince geoid he omputed eleva ING STATION N FROM 1002 4006 4006 4008 4009 4006 4006 4005 4005 4007 1002 STATION	A, LON., Eleights are ations may lations l	0843A 0843A 0833A 0833B 0833B 0833B 0833C 0833B 0833A 0843A 0833A 0843A 0833A 0843A	DX 7853.486 567.529 -864.618 -98.867 412.552 -1178.280 628.445 60.920 -1432.144 -313.662 6107.640 LONGIT	DY -20463.167 1059.329 -467.386 2094.641 -1492.436 -1069.587 613.864 -445.464 -1526.716 -602.201 -22591.898	DZ -22275.296 1045.274 -388.229 2228.220 -1614.997 -1001.466 569.761 -475.513 -1433.499 -613.237 -24322.208 LEV. G 162.300 149.529	LENGTH 31250.71 1592.75 1056.75 3059.78 2237.36 1880.23 1047.09 654.41 2537.08 914.92 33753.02
MISCI S: CC TART: LINE 23 10 12 16 18 13 9 24 8 14	LOSURES (LAT. ince geoid he omputed eleva ING STATION N FROM 1002 4006 4006 4008 4009 4006 4005 4005 4007 1002 STATION 1002 4005 4005 4005	A, LON., Eleights are ations may NAME: 1002 TO 4005 4007 4007 4008 4009 4004 4004 4007 4009 4009 LATT 43 43 43	0843A 0843A 0843A 0833B 0833B 0833B 0833B 0833B 0833A 0843A 0833A 0843A 0833A 0843A 0833B 0833C	DX 7853.486 567.529 -864.618 -98.867 412.552 -1178.280 628.445 60.920 -1432.144 -313.662 6107.640 LONGIT 123 84 0 174 83 5 309 83 5	DY -20463.167 1059.329 -467.386 2094.641 -1492.436 -1069.587 613.864 -445.464 -1526.716 -602.201 -22591.898 UDE EXIDE EXIDE CONTROL C	DZ -22275.296 1045.274 -388.229 2228.220 -1614.997 -1001.466 569.761 -475.513 -1433.499 -613.237 -24322.208 LEV. G 162.300 149.529 152.555	LENGTH 31250.71 1592.75 1056.75 3059.78 2237.36 1880.23 1047.09 654.41 2537.08 914.92 33753.02
S: CC TART: LINE 23 10 12 16 18 13 9 24 8 14	LOSURES (LAT. ince geoid he omputed eleva ING STATION N FROM 1002 4006 4006 4008 4009 4006 4005 4005 4007 1002 STATION 1002 4005	A, LON., Ending to a relations may later to a tions	0843A 0843A 0833A 0833B 0833B 0833B 0833C 0833B 0833A 0843A 0833A 0843A 0833A 0843A	DX 7853.486 567.529 -864.618 -98.867 412.552 -1178.280 628.445 60.920 -1432.144 -313.662 6107.640 LONGIT 123 84 0174 83 53 309 83 55	DY -20463.167 1059.329 -467.386 2094.641 -1492.436 -1069.587 613.864 -445.464 -1526.716 -602.201 -22591.898 UDE E 0 46.44187 6 34.06100	DZ -22275.296 1045.274 -388.229 2228.220 -1614.997 -1001.466 569.761 -475.513 -1433.499 -613.237 -24322.208 LEV. G 162.300 149.529	LENGTH 31250.71 1592.75 1056.75 3059.78 2237.36 1880.23 1047.09 654.41 2537.08 914.92 33753.02

Figure D-23. Loop closure, Upper Saginaw River project (Continued)

```
43 24 30.42676 83 58 1.20394

43 25 14.92339 83 57 4.11865

43 25 40.45206 83 56 33.45874

43 26 1.65202 83 56 34.06221

43 24 57.46234 83 57 44.52579

43 24 30.42681 83 58 1.20400
      4009
                                                                                146.844
                                                                                                 0.000
                                                                                                 0.000
       4006
                                                                                152.566
       4004
                                                                                148.995
                                                                                                 0.000
       4005
                                                                                149.540
                                                                                                 0.000
       4007
                                                                                157.216
                                                                                                 0.000
       4009
                                                                                146.848
                                                                                                 0.000
                                 43 42 37.45140 84 00 46.44218
      1002
                                                                                162.570
                                                                                                 0.000
TRAVERSE LENGTH = 79.984 kilometers
MISCLOSURES (LAT., LON., ELEV., meters):
                                                           0.005
                                                                       0.007
                                                                                  0.270
                                                                 LOOP MISCLOSURE =
                                                                                             3.4 ppm
    Since geoid heights are not given, the
   computed elevations may be seriously in error.
```

Figure D-23. (Concluded)

	F	ILLNET.IN	
6378137.0 298.2572		YNNN	
Fillnet Input File 1001	083084 FREE ADJ 43 33 32.67152	43.5 83.9 083 48 27.85821 150	.615
1 0 4008		083 57 49.93704 146	.842
2 0			
4009 3 0	43 24 30.42636	083 58 1.19634 146	.561
FFF 1002	43 42 37.45123	084 0 46.44187 162	.300
4 0 4004	43 25 40.44276	083 56 33.45850 148	.717
5 0 4005	43 26 1.64290	083 56 34.06171 149	.245
6 0			
4007 7 0	43 24 57.45316	083 57 44.52581 156	.933
4006	43 25 14.91409	083 57 4.11839 152	.287
8 0 *			
24 3 510 510 0.00 4 1001		0.00 0.00 0.00 0.00 -11172.423 -14312.145	-13760.192 610201020
1 2			
4 1001 1 3	4009 0833C	-11584.984 -12819.715	-12145.194 610201020
4 1002 4 1	1001 0833C	17692.643 -9772.176	-12177.017 610201020
4 1002	4008 0833C	6520.196 -24084.335	-25937.204 610201020
4 2 4 1002	4009 0833C	6107.640 -22591.898	-24322.208 610201020
4 3 4 4004	4005 0833A	-60.916 445.465	475.513
5 6			
4 4004 5 7	4007 0833A	-1493.060 -1081.250	-957.986
4 4005	4007 0833A	-1432.144 -1526.716	-1433.499
6 7 4 4006	4004 0833A	628.445 613.864	569.761
8 5 4 4006	4005 0833A	567.529 1059.329	1045.274
8 6			
4 4006 8 7	4007 0833A	-864.616 -467.386	-388.225
4 4006 8 7	4007 0833B	-864.618 -467.386	-388.229
4 4006	4009 0833B	-1178.280 -1069.587	-1001.466
8 3 4 4007	4009 0833B	-313.662 -602.201	-613.237
7 3			
4 4008 2 8	4006 0833B	765.751 2562.026	2616.450
4 4008 2 7	4007 0833B	-98.867 2094.641	2228.220
4 4008	4009 0833B	-412.530 1492.440	1614.982
2 3 4 4009	4008 0833C	412.552 -1492.436	-1614.997
3 2		-9778.301 -11136.364	
4 1001	4004 0843A	-2110.304	~103/3,636

Figure D-24. Input file for free adjustment, Upper Saginaw River project (Continued)

_		F	ILLNET.IN			
5 1001	4005	0843A	-9839.221	-10690.899	-10098.344	
6 1002	1001	0843A	17692.725	-9772.257	-12176.953	
1 1002	4004	0843A	7914.403	-20908.632	-22750.807	
5 1002 6	4005	0843A	7853.486	-20463.167	-22275.296	
400 5 5	4004	0843A	60.920	-445.464	-475.513	
5						

Figure D-24. (Concluded)

	RAM FII				.0.00)					
Fillı	net Ing	out Fi	le 08	3084	CONS	TRAI	NED	43	.5 83.9		
a = ST	637813	37.000	1/	f =	298.	2572	221	W	Longitude	positi	ve WE
PREL	EMINARY	COOR		S: LAT.				LON.	ELEV.	Сч	CON
STR.								2011.	THE 4.	G.n.	CON
1 2 3	FF	4008		18.3	9709	83	57	27.8609 49.9370	4 146.842	0.00	0
4	FFF	1002 4	43 42	37.4	5123	84	0	1.1963 46.4418	7 162.300	0.00	0
5 6			43 25 43 26		4276 4290	83 83	56 56	33.4585 34.0617	0 148.717 1 149.245		
7		4007 4	43 24	57.4	5316	83	57	44.5258	1 156.933		
8		4006	43 25	14.9	1409	83	57	4.1183	9 152.287	0.000	כ
GROUI	2 1, NO	. OF V	VECTOR	s ani	D BIA	s co	NSTI	RAINTS:			
24	0.	000	0.001	0.	.000	0.0	01	0.000	0.000	0.000	0.000
VECTO	RS:										
			DX		DY			DZ	LENGTH	ERROR CO	DDES
1001 0 4	4008	-111	172.42	3 -14	4312.	145 -	-137	60.192	22781.646	6102.0	102.
1001	4009	-115	584.98	4 -12	2819.	715 ·	-121	45.194	21120.196	6102.0	102.
1002	1001	176	592.64	3 -9	9772.	176 ·	-121	77.017	23596.711	6102.0	102.
1002	4008	65	520.19	6 -24	1084.	335 •	-259	37.204	35990.370	6102.0	102.
1002	4009	61	107.64	0 -22	2591.	898 -	-243	22.208	33753.028	6102.0	102.
4004	4005	-	-60.91	5	445.	465	4	75.513	654.418	3 51.0	51.
4004	4007	-14	193.06	D -1	L081.	250	-9	57.986	2077.515	3 51.0	51.
4005	4007	-14	132.14	1 –1	L526.	716	-14	33.499	2537.088	3 51.0	51.
4006	4004	6	528.44	5	613.	864	5	69.761	1047.091	3 51.0	51.
0 4 4006	4005	5	567.52	9 1	1059.	329	10	45.274	1592.754	3 51.0	51.
0 4 4006 0 4	4007	-8	364.61	5 -	-467.	386	-3	88.225	1056.754	3 51.0	51.

Figure D-25. Results of constrained adjustment, Upper Saginaw River project (Sheet 1 of 6)

4006	4007	-864.618	-467.386	-388.22	9 1056.757	3 51.0	51.
0 4 4006	4009	-1178.280	-1069.587	-1001.46	66 1880.238	3 51.0	51.
0 4 4007	4009	-313.662	-602.201	-613.23	7 914.926	3 51.0	51.
0 4 4008	4006	765.751	2562.026	2616.45	i0 3741.145		51.
0 4							
4008 0 4	4007	-98.867	2094.641	2228.22	0 3059.781	3 51.0	51.
4008 0 4	4009	-412.530	1492.440	1614.98	2 2237.348	3 51.0	51.
4009 0 4	4008	412.552	-1492.436	-1614.99	7 2237.360	3 51.0	51.
1001	4004	-9778.301	-11136.364	-10573.85	6 18205.499	3 51.0	51.
1001	4005	-9839.221	-10690.899	-10098.34	4 17694.127	3 51.0	51.
1002	1001	17692.725	-9772.257	-12176.95	3 23596.773	3 51.0	51.
1002	4004	7914.403	-20908.632	-22750.80	7 31896.832	3 51.0	51.
0 4 1002	4005	7853.486	-20463.167	-22275.29	6 31250.716	3 51.0	51.
0 4 4005 0 4	4004	60.920	-445.464	-475.51	3 654.417	3 51.0	51.
SHIF	Ts:						
1	0.000	0.000	0.102				
2	-0.190		0.238				
3	-0.181		0.226				
4	0.000		0.000				
5	0.097		0.222				
6			0.238				
7			0.223				
8	0.095		0.222				
ADJUS	TED VECT	ORS, GROUP	1:				
			DX,DY,DZ	V	DN, DE, DU	v v¹	
1001	4008	0833C	-11172.608		18960.149 0	.017 0.:	3
			-14312.293		12630.231 -0		
			-13760.130	0.105		.135 2.0	
1001	4009	0833C	-11585.141			.014 0.:	2
			-12819.845	-0.085 -	12881.834 -0	.048 -0.8	В
			-12145.133			.124 2.0	
1002	1001	0833C	17692.745	0.058 -	16815.857 -0	.014 -0.3	,
			-9772.339			.051 0.	
			-12177.068	0.052		.090 1.:	
				_	-		

Figure D-25. (Sheet 2 of 6)

1002	4008	0833C	6520.137	0.019	-35776.006	0.007	0.1
			-24084.632 -		3923.889		0.0
			-25937.198		20.048	0.214	2.1
			2030.1130	0.101	201040	0.214	2.1
1002	4009	0833C	6107.605	0.038	-33552.837	0.000	0.0
			-22592.184 -		3672.286		0.2
			-24322.201		23.486		2.2
						77275	
4004	4005	0833A	-60.916 -	-0.001	654.286	-0.000	-0.0
			445.467 -	-0.000	-13.234		-0.2
			475.516	0.000		0.000	0.0
4004	4007	0833A	-1493.074 -	0.001	-1325.757	-0.001	-0.2
			-1081.252	0.001	-1599.518		-0.2
			-957 . 990 -			-0.002	-0.3
4005	4007	0833A	-1432.158	0.000	-1980.043	-0.000	-0.0
			-1526.719		-1586.285		0.0
			-1433.505 -			-0.003	-0.4
					*****		004
4006	4004	0833A	628.451 -	0.000	787.486	-0.000	-0.1
			613.865 -		690.124		-0.1
			569.763		-2.121		0.1
4006	4005	0833A	567.535 -	0.002	1441.772	-0.000	-0.1
			1059.333 -	0.001	676.890		-0.3
			1045.278		-0.794		0.1
4006	4007	0833A	-864.623 -	0.001	-538.271	-0.001	-0.3
			-467.387		-909.394		-0.1
			-388.227 -			-0.002	-0.2
						*****	3.2
4006	4007	0833B	-864.623	0.001	-538.271	0.001	0.3
			-467.387		-909.394		0.2
				0.002	3.227	0.001	0.2
4006	4009	0833B	-1178.293 -	0.003	-1372.338	0.002	0.3
			-1069.590		-1285.281		-0.3
			-1001.467		-8.729		0.0
4007	4009	0833B	-313.670 -	0.004	-834.066	0.000	0.1
			-602.203		-375.887		
			-613.240 -		-11.955		-0.1
					-		
4008	4006	0833B	765.761 -	0.006	3595.507	0.001	0.2
			2562.037 -		1033.678		-0.7
			2616.464		12.167		0.2
					-		-
4008	4007	0833B	-98.862 -	0.004	3057.236	0.003	0.4
			2094.651 -		124.284		-0.6
							-
ĺ							
L							

Figure D-25. (Sheet 3 of 6)

			2228.237	0.005	15.393	0.005	0.6
4008	4009	0833B	-412.532	-0.007	2223.169	0.004	0.7
			1492.448	-0.002	-251.603	-0.007	-1.0
			1614.997	0.006	3.438	0.004	0.6
4009	4008	0833C	412.532	-0.015	-2223.169	0.006	1.2
	1000		-1492.448		251.603		-1.9
			-1614.997		-3.438	0.007	0.9
1001	4004	00403	-9778.397	0.005	-14577.156	-0.004	-0.1
1001	4004	0843A	-11136.390		-10906.429		0.2
			-10573.904			-0.022	-0.8
			-10573.904	-0.017	-0.012	-0.022	0.0
1001	4005	0843A	-9839.312		-13922.870		-0.1
			-10690.923		-10919.663		0.3
			-10098.389	-0.016	1.314	-0.020	-0.8
1002	1001	0843A	17692.745	-0.024	-16815.857	0.001	0.0
1000			-9772.339		16554.120		-0.7
			-12177.068		30.106	-0.019	-0.5
1002	4004	0843A	7914.349		-31393.013		0.0
			-20908.729		5647.691		0.1
			-22750.972	-0.032	30.094	-0.048	-1.0
1002	4005	0843A	7853.433	0.002	-30738.727	0.003	0.1
			-20463.262	0.036	5634.457	0.005	0.1
			-22275.456	-0.030	31.421	-0.046	-1.0
4005	4004	0843A	60.916	-0.003	-654.286	-0.000	-0.1
4005	4004	004511	-445.467			-0.003	-0.4
			-475.516		-1.327		0.0
S.E. C	OF UNIT	WEIGHT =	0.843				
	R OF -						
	. EQUATI	ons	74				
	ROWNS		23				
	REES OF	FREEDOM	51				
ITE	RATIONS		0				
) 1400 CC		. (mm=) -		
GROUP	1 ROT.	ANGLES (sec.) AND SC	ALE DIFF	. (ppm):		
HOR.	SYSTEM	0	.000 0.000	0.657	5.277		
	ERRORS	0	0.001	0.166	0.804		
	YSTEM	0.	051 -0.473	0.452	:		
		mrove:					
ADJUS:	red Posi	TIONS:					

Figure D-25. (Sheet 4 of 6)

(m)			LAT.		L	on.		ELEV.	STD	ERRO	RS
1	1001	43 3	3 32.66675	83 4	48	27.860	95	150.717	0.000	0.000	٥.
019 2	4008	43 2	3 18.39093	83 9	57	49.948	60	147.080	0.024	0.024	ο.
019 3	4009	43 2	4 30.42050	83 !	58	1.206	57	146.787	0.022	0.023	٥.
019 4	1002	43 4	2 37.45123	84	0	46.441	87	162.300	0.000	0.000	0.
000 5	4004	43 2	5 40.44591	83 !	56	33.460	51	148.939	0.020	0.020	٥.
019 6	4005	43 2	6 1.64599	83 !	56	34.063	78	149.483	0.020	0.020	0.
019 7	4007	43 2	4 57.45612	83 5	57	44.527	99	157.156	0.022	0.022	0.
019	4006	43 2	5 14.91718	83 5	57	4.120	68	152.509	0.021	0.021	ο.
019	DACTEC	(m) -									
ACCO	RACIES	(m);		D.	. L	AT.	D.	LON.	VERT.		
100	1	4	008	(0.0	24	٥.	024	0.014		
100	1	4	009	(0.0	22	О.	.023	0.014		
100	2	1	.001	(0.0	00	0.	.000	0.019		
100	2	4	008	(0.0	24	0.	024	0.019		
100	2	4	009	(0.0	22	0.	023	0.019		
400	4	4	005	(0.0	02	0.	004	0.004		
400	4	4	007	(0.0	03	0.	004	0.004		
400	5	4	007	(0.0	03	0.	004	0.004		
400	6	4	004	(0.0	03	0.	004	0.004		
400	6	4	005		0.0			004	0.004		
400	6	4	007	(0.0	02	0.	.003	0.003		
400	6	4	007	(0.0	02	0.	.003	0.003		
400	5	4	009	(0.0	03	0.	004	0.004		
400	7	4	009	(0.0	03	0.	004	0.004		
400	3	4	006	(0.0	04	Ο.	005	0.004		
400		_	007		0.0			005	0.004		
4008			009		0.0			004	0.004		
4009			008		0.0			004	0.004		
100	_		004		0.0			020	0.014		
100			005		0.0			020	0.014		
100			.001		0.0			000	0.019		
100			004		0.0			020	0.019		
100			005		0.0			020	0.019		
400	Ō	4	004	(0.0	02	ο.	004	0.004		
***** ****	*****	****	*****	****	***	*****	***	*****		**** ****	

Figure D-25. (Sheet 5 of 6)

****		ESTIMA	TES OF 1	PRE	CISION			**** ****
****	-		mon 100	TT 8.4	TEC			****
***	В	ased on the VEC			les prod	ucea by		****
****			FILLNE	Ľ				****
***	mı. i	_ !						****
**** ****		s is a reasonab f the vectors i					25	****
****	0.	t the vectors i	n the n	3 CWC	ork at 1	SIGMA.		***

****	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		****					
VEC	CTOR	LENGTH	PPM(h)	R	ATIO(h)	PPM(v)	R	ATIO(V)
1001	4008	22781.793	1.5	1:	671215	0.6	1:	1627271
1001	4009	21120.326	1.5	1:	663584	0.7	1:	1508595
1002	1001	23596.882	0.0	1:	0	0.8	1:	1241941
1002	4008	35990.553	0.9	1:	1060382	0.5	1:	1894240
1002	4009	33753.209	0.9	1:	1060499	0.6	1:	1776485
4004	4005	654.421	6.8	1:	146333	6.1	1:	163605
4004	4007	2077.527	2.4	1:	415504	1.9	1:	519382
4005	4007	2537.102	2.0	1:	507420	1.6	1:	634275
4006	4004	1047.096	4.8	1:	209419	3.8	1:	261774
4006	4005	1592.761	3.1	1:	318552	2.5	1:	398190
4006	4007	1056.761	3.4	1:	293091	2.8	1:	352254
4006	4007	1056.761	3.4	1:	293091	2.8	1:	352254
4006	4009	1880.249	2.7	1:	376046	2.1	1:	470062
4007	4009	914.932	5.5	1:	182971	4.4	1:	228733
4008	4006	3741.164	1.7	1:	584269	1.1	1:	935291
4008	4007	3059.800	2.1	1:	477854	1.3	1:	764950
4008	4009	2237.364	2.2	1:	447472	1.8	1:	559341
4009	4008	2237.364	2.2	1:	447472	1.8	1:	559341
1001	4004	18205.594	1.6	1:	643665	0.8		1300400
1001	4005	17694.218	1.6	1:	625585	0.8	1:	1263873
1002	1001	23596.882	0.0	1:	0	0.8	1:	1241941
1002	4004	31897.000	0.9	1:	1127729	0.6		1678789
1002	4005	31250.879	0.9	1:	1104885	0.6		1644783
4005	4004	654.421	6.8	1:	146333	6.1	1:	163605

Figure D-25. (Sheet 6 of 6)

```
083084C.SPC
;Software: CORPSCON v3.01, Agency: CORPS OF ENGINEERS SAGINAW
;Project: UPPER SAGINAW MAPPING,
Original Coordinates on NAD 83 Geographic Coordinates
Translated Coordinates on NAD 83 State Plane Zone 2113, U.S. FOOT
1001 JONAS
                    ,13271491.47735,
                                     750899.10875
4008 WICKS
                    ,13230401.67183,
                                     688469.29439
4009 RUST
                    ,13229535.79827,
                                     695757.90291
1002 PARRISH
                  ,13216876.80162,
                                     805765.50958
4004 HOYT
                   ,13235976.88650,
                                     702879.28348
4005 GENESSEE
                                     705025.46304
                  ,13235921.56530,
4007 EWALD
                  ,13230753.74995, 698500.99009
4006 HOLLAND
                   ,13233727.24329, 700283.34945
```

Figure D-26. CORPSCON file, Upper Saginaw River project

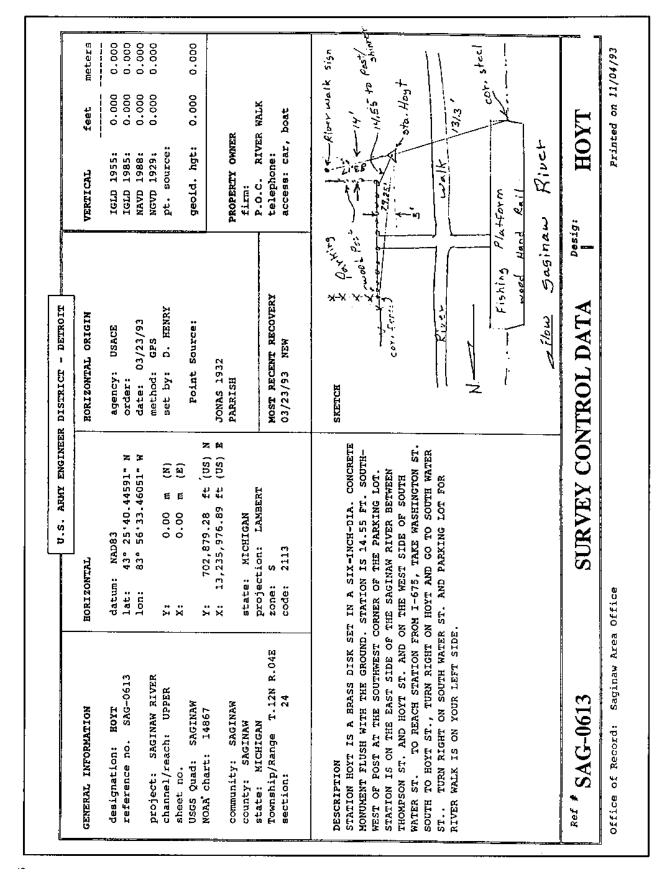


Figure D-27. Descriptions of Stations Hoyt, Wickes, Eward, Rust, Holland, and Genesee (Sheet 1 of 6)

Figure D-27. (Sheet 2 of 6)

	U.S. ARMY ENGINEER DISTRICT	ER DISTRICT - DETROIT			
GENERAL INFORMATION	BORIZONTAL	RORIZONTAL ORIGIN	VERTICAL	feet	meters
щ	n: NAD83	agency: USACE	IGLD 1955;		0.000
reference no. SAG-0611	lat: 43° 24'57'45512" N	order: date: 03/23/93			
project: SAGINAW RIVER		method: GPS	NGVD 1929:	0.000	0.000
channel/reach: UPPER	Y: 0.00 m (N)	set by: D. HENRY	pt. source:		
	E	4	404 61000	•	000
USGS Quad: SAGINAW	W (20) +3 60 00 809 .v	Forne Source:		ı	
NORM CHALL	5 ft (US)	JONAS 1932			
community: SAGINAW		PARRISH	PROPERTY OWNER	WINER	
county: SAGINAW					
7	ť			ON BRIDGE	
Township/Range T.12N R.04E			rerepuone:	:	
section: 26	code: 2113	03/23/93 NEW	access: , nike	nike	
DESCRIPTION STATION EWALD IS A BRASS DISK SET INTO A CONCRETE SIDEWALK ON THE UPSTREAM SIDE OF THE COURT STREET BRIDGE OVER THE SAGINAW RIVER IN THE CITY OF SAGINAW. STATION IS 475 FT. IS AT THE FIRST OBSERVATION PLATFORM FROM THE WEST SIDE OF THE BRIDGE. TO REACH COURT STREET BRIDGE FROM I-675, TAKE M-13 (WASHINGTON) SOUTH TO RUST DRIVE, TURN RIGHT AND IT TAKES YOU ACROSS THE COURT STREET BRIDGE AND STREET TURNS INTO COURT STREET.	SET INTO A CONCRETE SIDEWALK URT STREET BRIDGE OVER THE AGINAW. STATION IS 475 FT. REET FROM STATION. STATION ATFORM FROM THE WEST SIDE OF REET BRIDGE FROM I-675, TAKE T DRIVE, TURN RIGHT AND IT EET BRIDGE AND STREET TURNS	SKETCH S Start Bound Start Bound Steel Hard Ravil	The septimb reserves	SABINOUS ENRO	is a mely
Ref * SAG-0611	SURVEY COP	SURVEY CONTROL DATA	Desig: E	EWALD	

Figure D-27. (Sheet 3 of 6)

Figure D-27. (Sheet 4 of 6)

	U.S. ARMY ENGINEER	R DISTRICT - DETROIT			
GENERAL INFORMATION	HORIZONTAL	BORIZONTAL ORIGIN	VERTICAL	feet	meters
designation: HOLLAND reference no. SAG-0608	datum: NAD83 lat: 43°25'14.91718"N	agency: USACE order: date: 03/23/93	IGLD 1955: IGLD 1985: NAVD 1988:	0.000	0.000
S C S	0.00 m (E)	# 7 #	NGVD 1929: pt. source: geold. hgt:	0.000	0.000
NOAR chart: 14867 community: SAGINAW county: SAGINAW state: MICHIGAN Township/Range T.12N R.04E section: 25	<pre>X: 700,283.35 ft (US) N X: 13,233,727.24 ft (US) E state: MICHIGAN projection: LAMBERT zone: S code: 2113</pre>	JONAS 1932 PARRISH MOST RECENT RECOVERY 03/23/93 NEW	PROPERTY OWNER firm: P.O.C. telephone: access: , hike	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	
DESCRIPTION STATION HOLLAND IS A STANDARD BRASS DISK SET INTO A CONCRI WALK ON THE UPSTREAM SIDE OF THE HOLLAND AVE. BRIDGE OVER THE SAGINAW RIVER. STATION IS ON THE EAST-BOUND SIDE OF SAID FOUR-LANE BRIDGE. REMINGTON ST. GOES TO THE WEST ACROSS THE BRIDGE AND HOLLAND ST. GOES TO THE EAST ACROSS THE BRIDGE.	A STANDARD BRASS DISK SET INTO A CONCRETE SIDE OF THE HOLLAND AVE. BRIDGE OVER STATION IS ON THE EAST-BOUND SIDE OF SE. REMINGTON ST. GOES TO THE EAST ACROSS ND HOLLAND ST. GOES TO THE EAST ACROSS	ESPECION SALVES OF THE SALVES	The Association of the Associati	Reming 52A Holland	63× 61×14×5×2
Ref * SAG-0608	SURVEY CONTROL DATA		Desig: HOLLAND	LANI	
Office of Record: Saginaw Area Off	a Office		Prin	Printed on 11/04/93	1/04/93

Figure D-27. (Sheet 5 of 6)

Figure D-27. (Sheet 6 of 6)